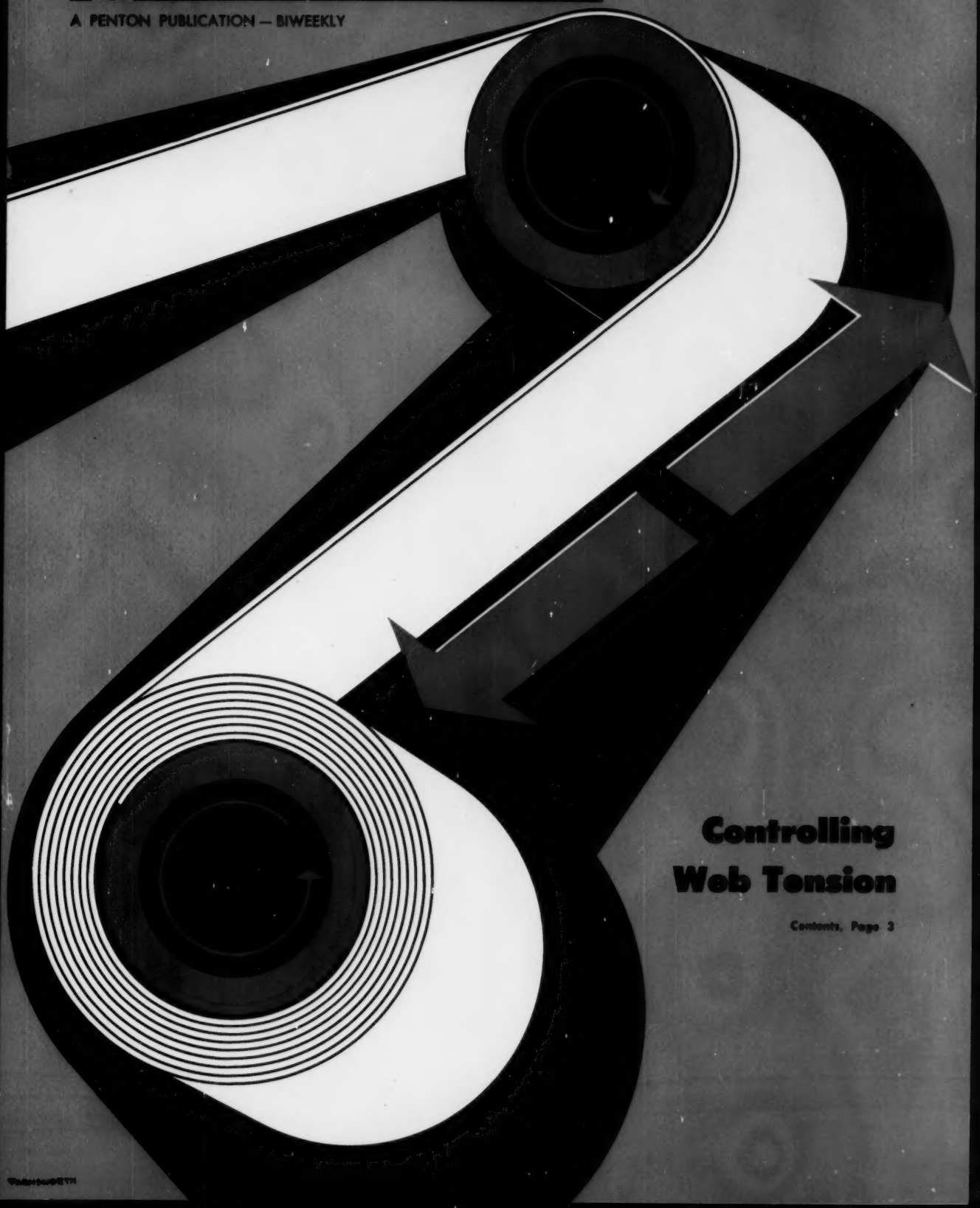
OCTOBER 29, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Controlling Web Tension

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This is a new HiLube® sintered bronze bearing. It is treated with moly sulfide, is self-lubricating, and holds almost a third more oil than other sintered bronze bearings. It runs cool and quiet at high speeds. It will last far longer than any other bearing of its kind. HiLube is one of many special bearing materials developed by Bound Brook.

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

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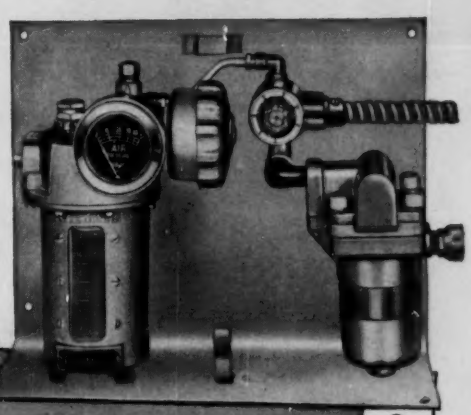
How to choose a

LUBRICATION SYSTEM

that provides constant, uniform lubrication

at savings of up to **90%**



use this handy check list:

Will your lubrication system be fully automatic? Oil-Mist starts and stops at the touch of your machine switch.

Will the system that you choose cut oil consumption by 90%? With the Alemite Oil-Mist System you can get better bearing lubrication with only 1/10th as much oil as required by other methods.

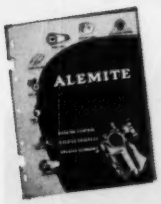
Will your lubrication system reduce bearing temperatures? The answer is "yes," if it's an Alemite Oil-Mist System. Reduction in fluid oil friction—plus air flow through bearing—greatly cuts bearing heat.

Will your system extend bearing life? You can definitely count on it, if you choose Oil-Mist. Oil-Mist has extended the service life of many bearings, even under adverse operating conditions, from 10 to 12 times!

Will you have a continuous system? Oil-Mist constantly feeds a uniform volume of fresh oil to each bearing. No oiling schedules. No feast-or-famine lubrication.

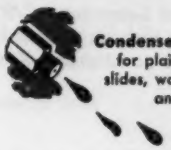
Does it protect against contamination? Satisfied Oil-Mist users say yes. A constant flow of clean, air-oil mixture—Oil-Mist—through bearings keeps out dirt and abrasives. Oil-Mist also eliminates wasteful oil handling and applying.

Lubricates any bearing on any machine in One Of Three Ways:



Oil-Mist for high speed anti-friction type of bearings.

Oil Spray for low speed anti-friction and open and enclosed gears and chains.



Condensed Oil for plain bearings, slides, ways, vees, cams, and rollers.

MAIL COUPON for Oil-Mist demonstration and information

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

Alemite, Division of Stewart-Warner, Dept. BB-109
1850 Diversey Parkway, Chicago 14, Illinois

☐ Please send me a free copy of your Oil-Mist catalog.

☐ Please have your Alemite Lubrication Representative arrange a no-obligation demonstration.

Name.....

Company.....

Address.....

City.....Zone.....State.....

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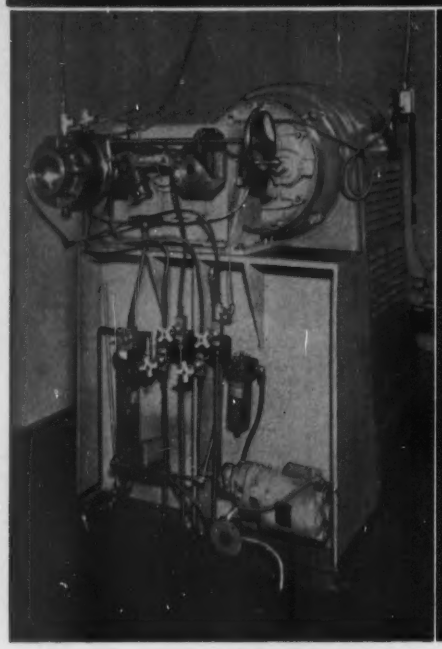
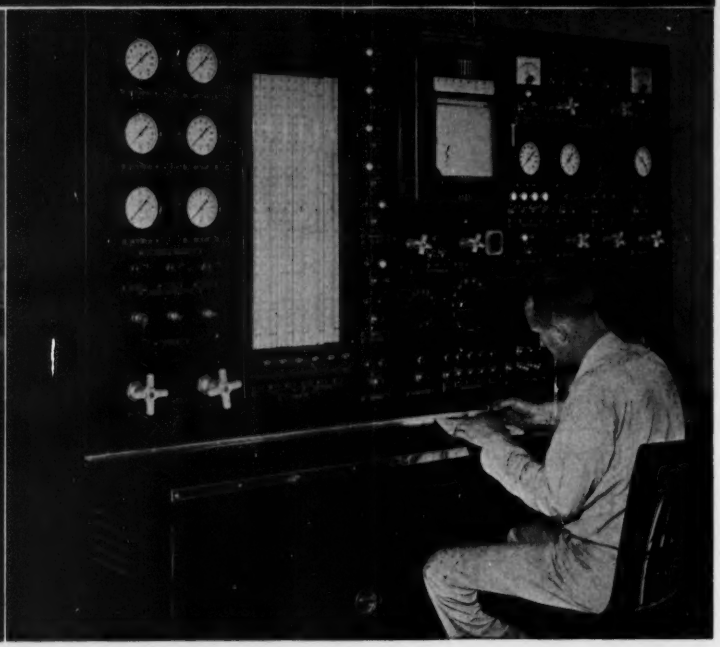
Breakthrough





New C/R high-speed laboratories ...testing seals at tomorrow's speeds!

Pushing a design program through on schedule means that there can be no slow-down in any phase. If you know there's a high-speed sealing problem ahead — an accessory drive for a new jet, a hot, fast-rotating shaft in a guided missile, or a bearing in tomorrow's turbine car — plan for it now. Here in Chicago Rawhide's new High-Speed Seal Test Laboratory, C/R engineers now are breaking through present limits, evaluating the design and performance of advanced seal types such as end face, controlled gap, bellows, segmental and bore type seals under such punishing conditions as 80,000 R.P.M., −300° to +1000°F. and 500 psi. C/R is at your service *now* with the most advanced technology and facilities in the country for cooperative research on high-speed sealing problems.

Chicago Rawhide consistently gears itself to the future, ready to meet industry's new problems as they develop today. May we help you?

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.
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Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

C/R OIL SEAL DIVISION

CHICAGO RAWHIDE

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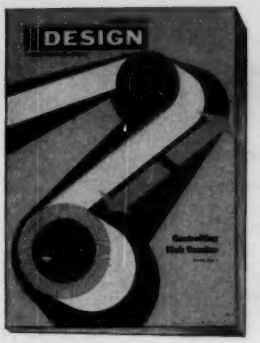

Front Cover: Many processing operations require careful control of tension in a web or strand of material. George Farnsworth's cover shows the problem, and E. H. Dinger's article on Page 122 tells how dc electric motor drives can provide the answer.

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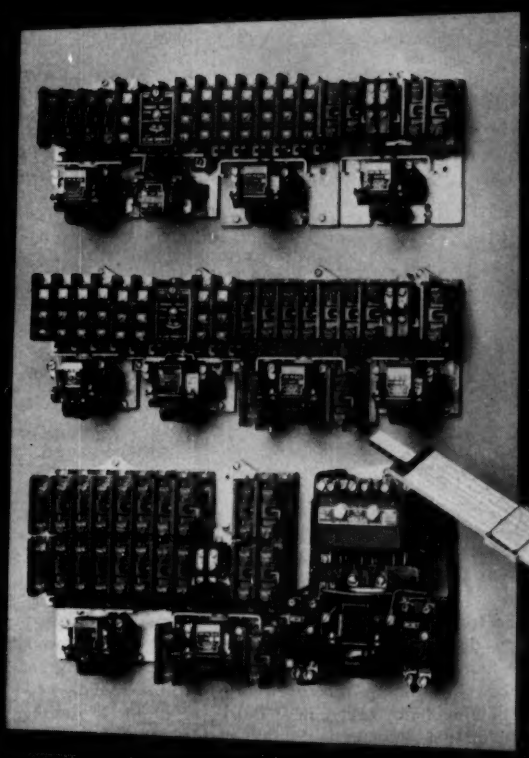
WHY SPACE IS
FRONT-PAGE NEWS...



Compact Clark Relays control 72 circuits from panel area smaller than a newspaper

In this day of space exploration and space economy, it's news—front page news—when you can get 72 separate, controlled circuits all on a panel no larger than 15" x 20".

Clark Controller, with the most complete and integrated line of control relays available today—convertible pole, latch, universal pole, and time delay—does it! And only Clark offers such a wide range of operation, so many contacts, in a panel area of such small size.

Shown mounted here with the Clark Size 1, Type "CY" Starter are 10 compact Clark Relays which include four time delay contacts (two normally open, two normally closed), 52 instantaneous contacts (14 normally open, 14 normally closed, and 24 convertible), plus 16 latching contacts (all convertible).

The same engineering leadership and superior workmanship that made Clark Controller the *standard of quality* for controls in heavy industry, is inherent in the broad line of Clark Relays for modern panels.

The "modular construction" of all Clark "PM" Relays insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space. And because "PM" relays are available in a wide variety of pole combinations, providing up to 14 contacts on a single relay, you can control more circuits—save on relay requirements.

For more information on the complete line of Clark "PM" Relays which is making space-saving headlines, contact your nearest Clark Controller sales office or distributor. Or, write direct to Clark Controller for free bulletins.

The **CLARK CONTROLLER** *Company*

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ENGINEERING NEWS

Instruments on Explorer VII Powered by Solar Cells

System Proved Practical By Earlier Satellite

WASHINGTON—Solar power for satellite electronic gear is here to stay. Unlike the chemical batteries of earlier satellites, it never wears out.

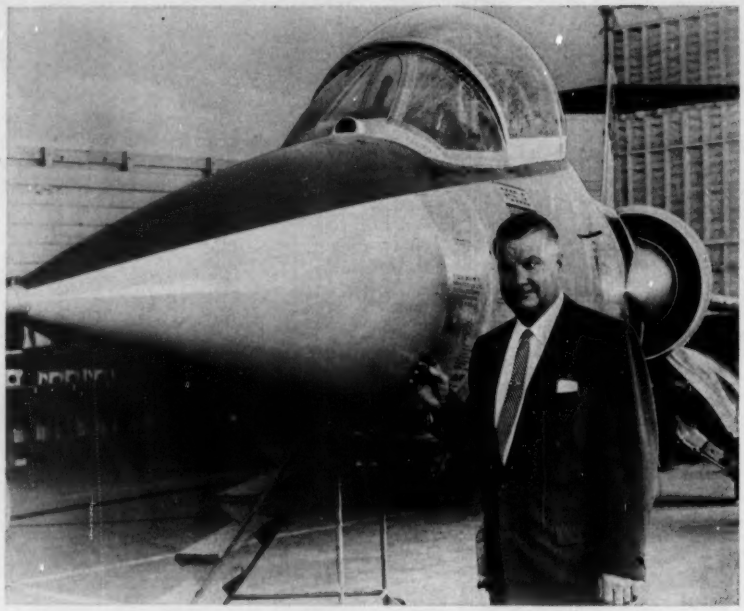
The composite radiation satellite launched October 13 from Cape Canaveral is the second U. S. satellite to use the sun for powering its radio and instruments. Vanguard I proved the system earlier in the year. Its solar-powered radio went on the air immediately on exposure to the sun and promises to continue transmitting indefinitely.

The new 91.5-lb "moon" is girdled by two rings of solar cells—2866 cells in all. The cells convert sunlight to five watts of electrical power, and will continue to do so for as long as the satellite stays in orbit. During the "daytime," half the electricity generated is used by the instruments and radio, and half is used in charging nickel-cadmium batteries. The batteries, in turn, power the satellite during periods of darkness.

The solar cells are grouped in six equal-power units (three in each ring) to assure constant flow of electricity, regardless of spin or tumble of the vehicle in space. Each unit is capable of supplying the necessary power by itself. The units are arranged so that at least one group will be in full sunlight at all times when the vehicle is not in earth's shadow.

Each power unit is made up of six solar-cell clusters. Each cluster contains a different number of silicon wafers of two sizes—having either one or two square centimeter surfaces—because each cluster supplies a different instrument. Although the clusters are larger and 100 times more powerful than the Vanguard I clusters, the two types are similar in construction. Cells are imbedded in ceramic cement in aluminum trays. The trays are covered with fused silica windows that are held in place by aluminum frames and sealed by rubber gaskets.

The complete power source, consisting of two rings, fused silica covers and auxiliary nickel-cadmium batteries, weighs 22½ lb. Future assemblies of solar cells may weigh less if an additional test cluster on the satellite proves successful. This cluster is a group of cells unprotected by fused silica (from abrasion by meteorite dust). If data radioed back indicate the unprotected cells are undamaged, a weight savings of almost half could be effected on future satellites.



Starfighter Wins a Prize

Winner of this year's Collier Trophy—"for the greatest achievement in American aviation . . . as thoroughly demonstrated by actual use during the preceding year"—is Lockheed's F-104 Starfighter. The "manned missile" qualified by setting several new land-plane performance records during 1958: Speed, 1404 mph; altitude, 91,243 ft; time-to-climb, seven new marks at altitudes ranging from 3000 meters (9843 ft) all the way up to 25,000 meters (82,021 ft). The Collier trophy committee also named five men as co-recipients of this year's award: C. L. Johnson, above, vice president for advanced research projects at Lockheed and designer of the airframe; Neil Burgess and Gerhard Neumann, developers of GE's J79 turbojet engine; Lt. Col. Howard H. Johnson, pilot for the altitude mark; and Maj. Walter Irwin, pilot for the speed record. The Trophy is sponsored by the National Aeronautic Association and Look Magazine.

Employers of Engineers To Be Recognized by NSPE

WASHINGTON, D. C.—Beginning in 1960, a firm employing engineers will be honored each year by the National Society of Professional Engineers with the society's newly established Industrial Profession Development Award. This award is to be made to a company which, through its employment practices, has made "an outstanding contribution to the advancement and improvement of the engineering profession."

Besides recognizing forward-look-

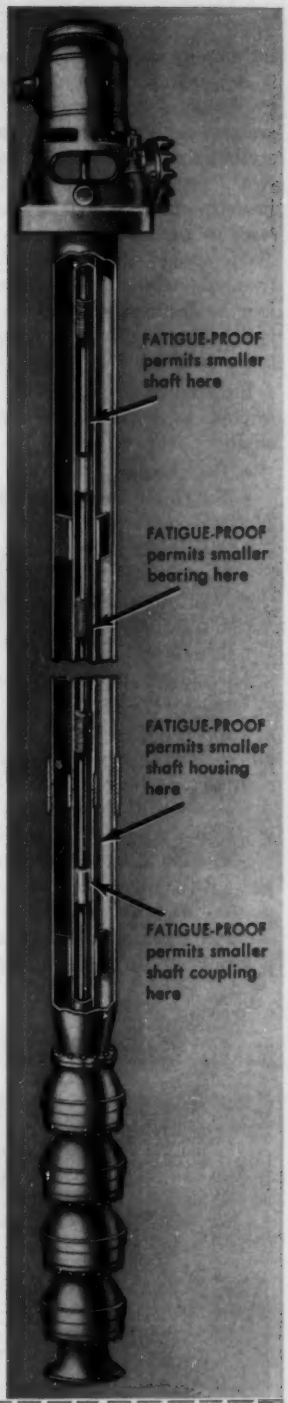
Salt River Valley Water Users Association,
Phoenix, Arizona

Saves $699.00 per pump...

by using ground and polished

fatigue-proof® STEEL BARS **e.t.d.**

made by elevated temperature drawing process


FATIGUE-PROOF permits smaller shaft here
FATIGUE-PROOF permits smaller bearing here
FATIGUE-PROOF permits smaller shaft housing here
FATIGUE-PROOF permits smaller shaft coupling here

The men who operate the "Salt River" project have the job of supplying water to 240,000 acres of land in Arizona, where the Gila River joins the Salt River. The Association maintains some 250 deep well pumps to help supply the required water.

Richard Juetten, Supervisor of Salt River's Pump Division, reports that the use of La Salle FATIGUE-PROOF steel bars has permitted a saving of $699.00 per pump . . . a potential saving of $174,750 when applied to the 250 pumps now in operation.

Mr. Juetten's report follows:

"I have figured our direct saving realized by using La Salle FATIGUE-PROOF steel bars in place of standard C-1045 steel shaft in our deep well turbine pumps.

"FATIGUE-PROOF enables us to use bars only $1\frac{11}{16}$" in diameter . . . instead of $2\frac{3}{16}$" diameter shafts which were necessary when we used C-1045 . . . and this despite higher horsepower, more weight, and additional pump bowl assemblies.

"Here are comparative costs per 10-foot section (of a 300-foot pump shaft):"

using C-1045		using FATIGUE-PROOF	
10' x 2-3/16" dia. shaft	$28.30	10' x 1-11/16" dia. FATIGUE-PROOF	$22.59
3½" shaft housing	26.30	3" shaft housing	19.80
2 bearings, 3½" x 2-3/16"	21.72	2 bearings, 3" x 1-11/16"	13.46
Shaft coupling	5.16	Shaft coupling	2.34
TOTAL cost	$81.48	TOTAL cost	$58.19
Cost per foot	$ 8.15	Cost per foot reduced to	$ 5.82

RESULT: A saving of $2.33 per foot . . . or $699.00 when applied to a 300-foot pump setting. And this doesn't take into consideration reduced power consumption.

La Salle STEEL CO.

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Hammond, Indiana

ASK FOR 24-PAGE BOOKLET—It tells the complete story of FATIGUE-PROOF®

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Circle 407 on Page 19

ing employment practices, the award is expected to encourage industrial employers of engineers to adopt progressive methods in accordance with established professional standards. NSPE president Harold A. Mosher has also observed that an important facet of the award program will be "wide-spread dissemination of information about some of the excellent professional development programs now available to engineers in industry."

Employment practices to be considered in making the award include:

- Registration
- Education and technical training
- Technical and professional society membership
- Working conditions
- Utilization
- Engineering titles
- Engineer-management communications

Local chapters of NSPE will submit nominations for the award, and a committee will choose the recipient. A plaque will be presented at the NSPE annual meeting, and the society magazine, the *American Engineer*, will carry an article giving reasons for the selection and outlining development of employment practices of the firm honored.

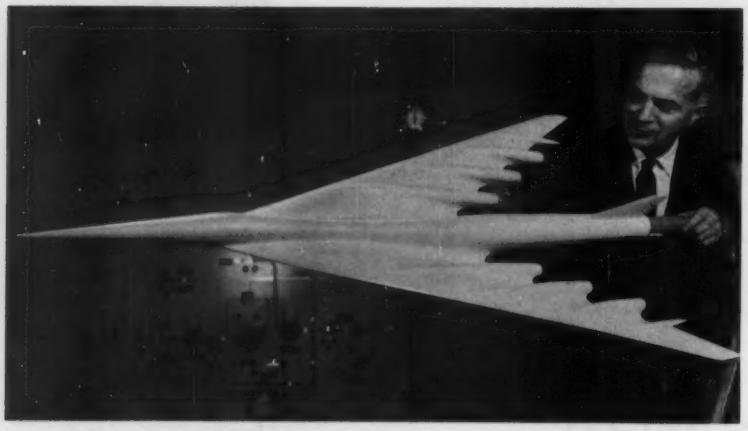
GIs May Fight in Air-Conditioned Suits

PITTSBURGH—A thermoelectric heater-cooler combination for fabrics will keep the future fighting man warm when he is in the arctic and cool when he is in the tropics. The air-conditioning unit, under development by Westinghouse Electric Corp., will be built into an experimental garment by the Navy.

The lightweight, impermeable and insulated garment will be the first cooled suit ever developed, even though heated suits have already found widespread military application. No light, compact portable air cooler has been available for this purpose, but thermoelectric air conditioning is now sufficiently developed to provide a unit able to supply the proper amount of cooling.

The air conditioner will consist of three main components: A thermoelectric unit will heat or cool the fabrics as necessary; a lightweight, rechargeable battery will supply power; and a blower will circulate air inside the suit. Comfortable internal temperatures will be maintained even when outside temperatures are as low as −40 or as high as 135 F. Batteries will supply enough power for at least one hour of operation, and the suit will also be designed for plug-in operation.

NASA Grooms Mach-3 for Commercial Consumption



Area-rule fuselage and boundary-layer fences mark this NASA model transport as a Mach 2-3 configuration. Fences, formed by the engine nacelles, minimize spanwise flow with its resulting high drag. According to NASA, a full-scale airplane designed along the lines of the six-engine model could be operated as efficiently as current subsonic transports. Shown with the model is NASA scientist Richard T. Whitcomb, who won the Collier Trophy in 1954 for the Area Rule

Topics

Moonquake measurements are to be taken by a 10 to 20-lb, lunar-based seismograph which the NASA hopes will be landed on the moon in five or six years. The seismograph would radio recorded tremors back to earth. The project is being researched at Columbia University and California Institute of Technology.

• • •

Plastic pipe goes underground to irrigate a new 18-hole golf course and driving range located at the southern tip of Lake Tahoe in California. Believed to be the first installation in the country with all branch lines made of plastic pipe and fittings, the system uses almost 2⅓ miles of Goodrich's Koroseal pipe and 1010 fittings. Advantages of the plastic pipe are corrosion resistance, smooth interior finish which permits a 25 per cent higher flow rate than metal pipe, and its ability to be "snaked" to follow irregular lines.

• • •

Removing the drudgery from fishing, a new electrical gadget scales a fish in a few minutes. It is powered by a quarter-inch electric drill; other attachments sharpen hooks and polish spoons and reels.

• • •

Chicks that live in plastic houses are healthier and less expensive to raise than those kept in wooden coops. This is the opinion of a California poultryman who recently used Union Carbide's polyethylene film to cover sides and tops (the latter of black film) of two buildings having a capacity of 20,000 chicks each. The film shuts out rain and drafts, lets in sunlight, and permits raising or lowering the sides according to the weather. Cost is about one-fifth that of a wooden chickenhouse.

• • •

Do-it-herself shoe repairs can be performed by the lady who wears shoes with spike heels made by Fitz-On Heel Corp. During manufacture, a Standard Pressed Steel Co. spring pin is inserted in the heel to reinforce it and also to serve as a socket receptacle for a molded plastic heel lift attached to a stem which fits in the spring pin. Replacement of lifts is accomplished merely by pulling out the worn one with a pair of pliers and inserting a new one.

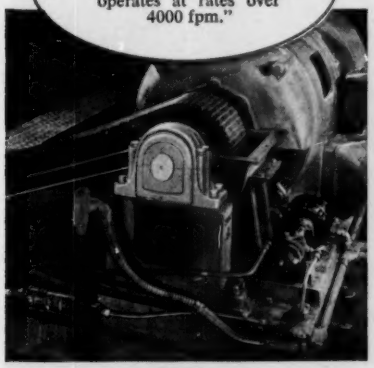
• • •

Wash and deal playing cards are among the latest offerings for that fellow who has everything else. All plastic, they can be tossed into the washing machine, are guaranteed to last as long as 573 decks of ordinary cards, and cost just $10 for two decks.

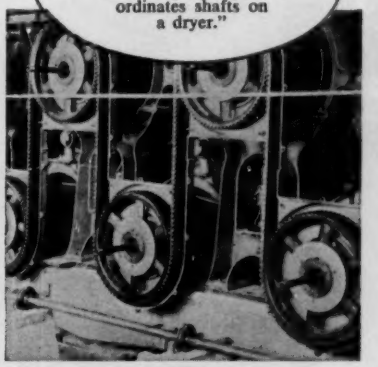
"Here's the story—why so many of

today's designs call for LINK-BELT Silent Chain"

"When it comes to speed, we find Link-Belt Silent Chain is tops. It often operates at rates over 4000 fpm."

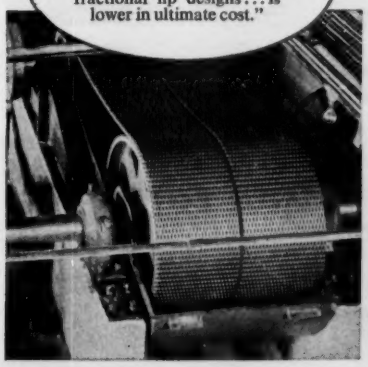


"You can count on Silent Chain for designs calling for accurate timing. Here Duplex Type co-ordinates shafts on a dryer."

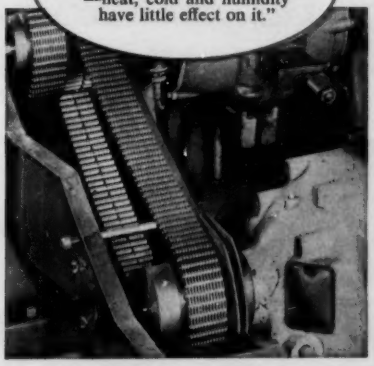


"Silent Chain can be installed on extremely short centers at ratios as high as 10-to-1, with resulting space economies."

"Link-Belt Silent Chain delivers better-than-98% efficiency on large or fractional hp designs... is lower in ultimate cost."



"You can specify Link-Belt Silent Chain confidently under all conditions —heat, cold and humidity have little effect on it."



"In close quarters, as in this belt sander 3/8 in. pitch Silent Chain permits built-in drives, compact housings."

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

FULL DETAILS on Link-Belt Silent Chain are offered in 88-page Book 2425. Get your copy from your Link-Belt office. Look under CHAINS in the yellow pages of your phone book.

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Shoot and Scoot

PHILOSOPHY behind America's future Army is not only to "get there firstest with the mostest," but once there, to leave almost immediately after pulverizing everything in sight.

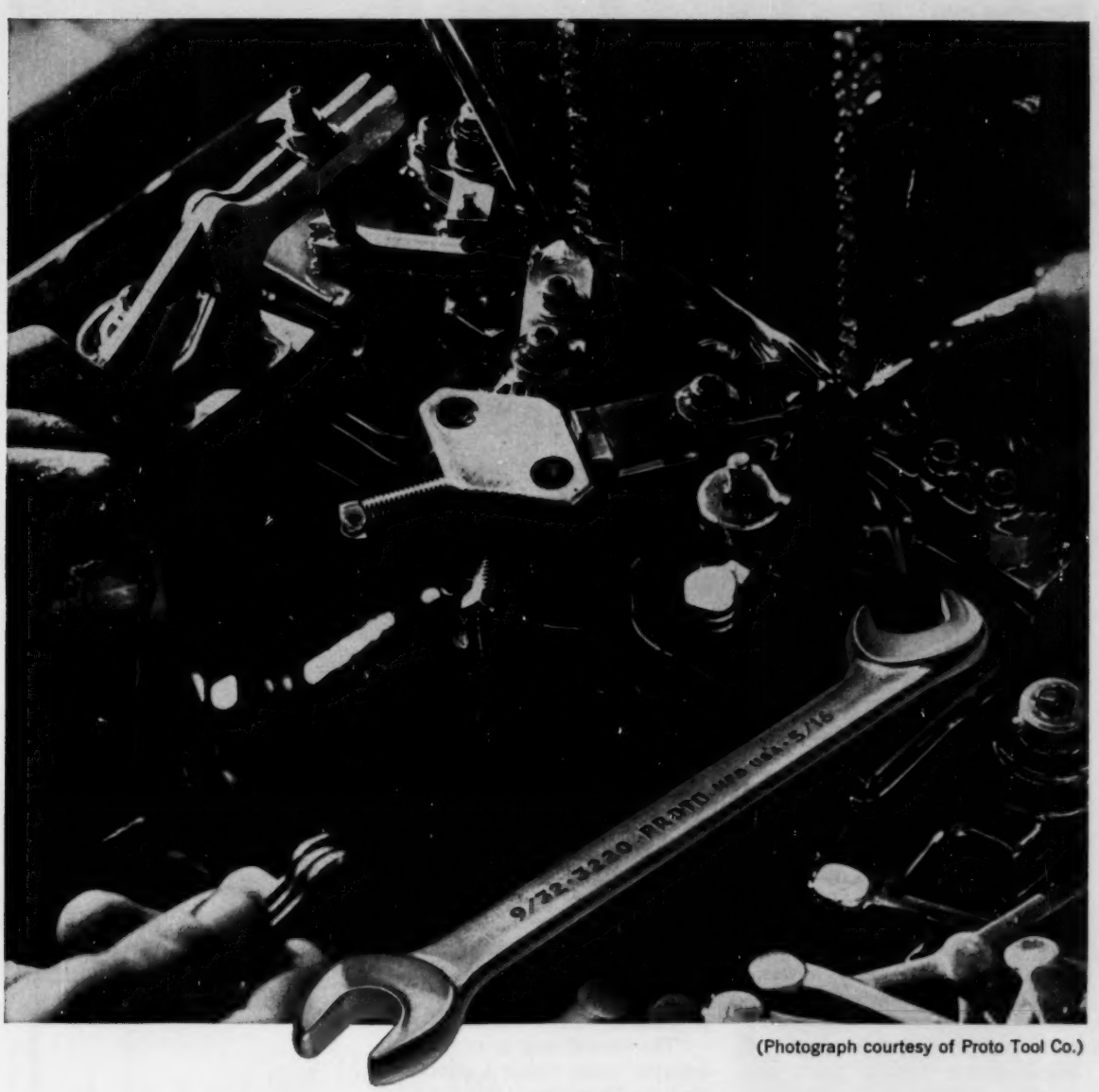
To accomplish this mission, Army Ordnance experts are assembling an impressive array of agile, lightweight weapon and personnel carriers that have tremendous firepower-to-weight advantages over comparable World War II vehicles. Some of the newest and best, demonstrated at the recent American Ordnance Association meeting at Aberdeen Proving Ground, Md., are shown here.

All of the land-based vehicles are built largely of aluminum, which reduces weight, in some instances, to almost half that of World War II counterparts. All are air transportable. Mechanically, the new weapon systems are as simple as engines, chassis, and guns can possibly be, and the military's human-factors experts have concentrated on making them exceptionally easy to operate.

Guided-missile team riding a turbine-powered helicopter can skim to a battle-front position at 150 mph, unload and launch the missile, and be ready for re-deployment before comparable land-based equipment is barely under way.

Aluminum armored and amphibious, Army's new 105-mm howitzer is 8 tons lighter than its predecessor. Recoil mechanism has been modified to permit quick change of tubes. Counter-recoil is accomplished by an external buffer.

Convertible utility ¾-ton truck, left, is an experimental dual-purpose vehicle having characteristics of the Jeep and the Mule. Seats fold out of the way to provide a flat cargo surface. Payload is 1500 lb or five passengers and driver; maximum speed is 60 mph. BAT, right, is a 106-mm antitank weapon with Jeep mobility. The powerful, lightweight (474 lb) recoilless rifle has a tracer-firing machine gun mounted on its barrel for a gunsight.



(Photograph courtesy of Proto Tool Co.)

Uniform hardenability . . . prime requirement for high-speed broaching

The most demanding requirement of steel used in high-speed broaching operations is bar-to-bar and heat-to-heat uniformity. Even slight variations, particularly in hardness, can result in tool breakage, lost production time, and expensive retooling.

By controlled melting in electric furnaces, Copperweld produces a steel of uniform hardenability characteristics. This prime broaching steel, called Protoloy®, is manufactured for Proto Tool Company. Copperweld is willing and able to produce special steels for you to your particular specifications.

For complete information about the full range of Aristoloy A.I.S.I. standard analyses, call the Copperweld representative in your nearest large city . . . or write for NEW PRODUCTS & FACILITIES CATALOG.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

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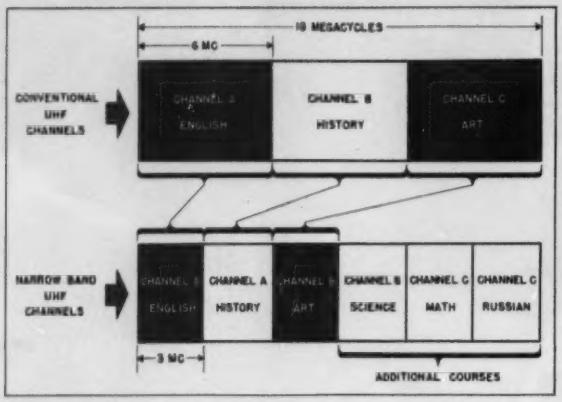
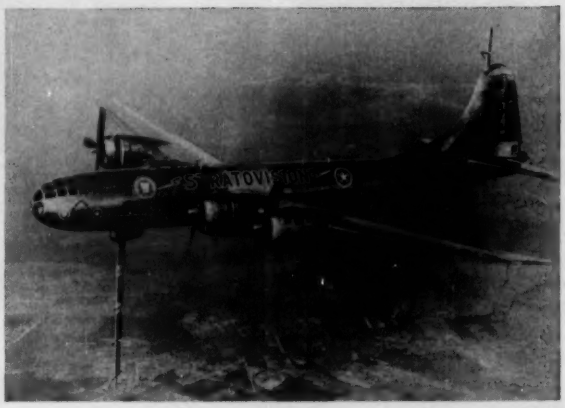
High-Flying Classroom Beams Lessons by TV





Quality instruction for 5 million students is the purpose of a new experiment in education. TV lessons beamed from an airplane at 20,000 ft will supplement efforts of classroom teachers in 17,000 locations next fall. The area serviced will include parts of Illinois, Indiana, Kentucky, Michigan, Ohio, and Wisconsin—approximately a circle, 300-400 miles in diameter. Conducted by the newly formed Midwest Council on Airborne Television Instruction and sponsored by private financing, the $7 million program will be transmitted from Purdue University, Lafayette, Ind., and relayed by the airplane. Instruction will be offered at all school levels—from grade school through college—to increase the quality of education on an economically feasible basis. Initial plans call for two channels; ultimately the number of channels for simultaneous broadcasts may be increased to six. "Narrow-band" transmission, using scanning systems different from those used in conventional TV, will double the number of channels available.

Fields Not Yet Developed Worry Engineering Educators

ITHACA, N. Y. — The accelerating pace of technological development is causing the time lag between discovery and application to practically disappear. This presents engineering educators with a serious problem, according to Cornell University's Dean of Engineering, Dale R. Corson. He says students today must be trained so that in five years, or less, they can work in fields that do not now exist.

Dean Corson concludes that the dilemma facing educators in the engineering field calls for two different curriculums. "We know that we must emphasize engineering science. An electrical engineer, for example, cannot build a supersensitive radio receiver using the latest developments in solid-state physics, unless he understands the physics involved.

"On the other hand, the country needs engineers who are going into manufacturing operations, management, or into any of the hundreds of other equally important areas which do not require so much scientific training."

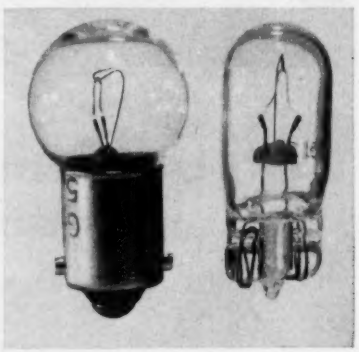
Dean Corson says there are two ways to meet these demands. The first is to provide engineering science through special curriculum as Cornell is doing in engineering physics. The five-year program offers a course firmly built on basic engineering discipline, but highly oriented toward mathematics and the sciences. It also includes a good program of liberal courses.

"The second way is to offer alternative paths within a given curriculum. This is being done to some extent in electrical engineering at Cornell. Beginning in the third year, a student can follow a normal engineering course or he can go rather heavily in a mathematics-physics direction."

Practical Solution To Another Growing Problem

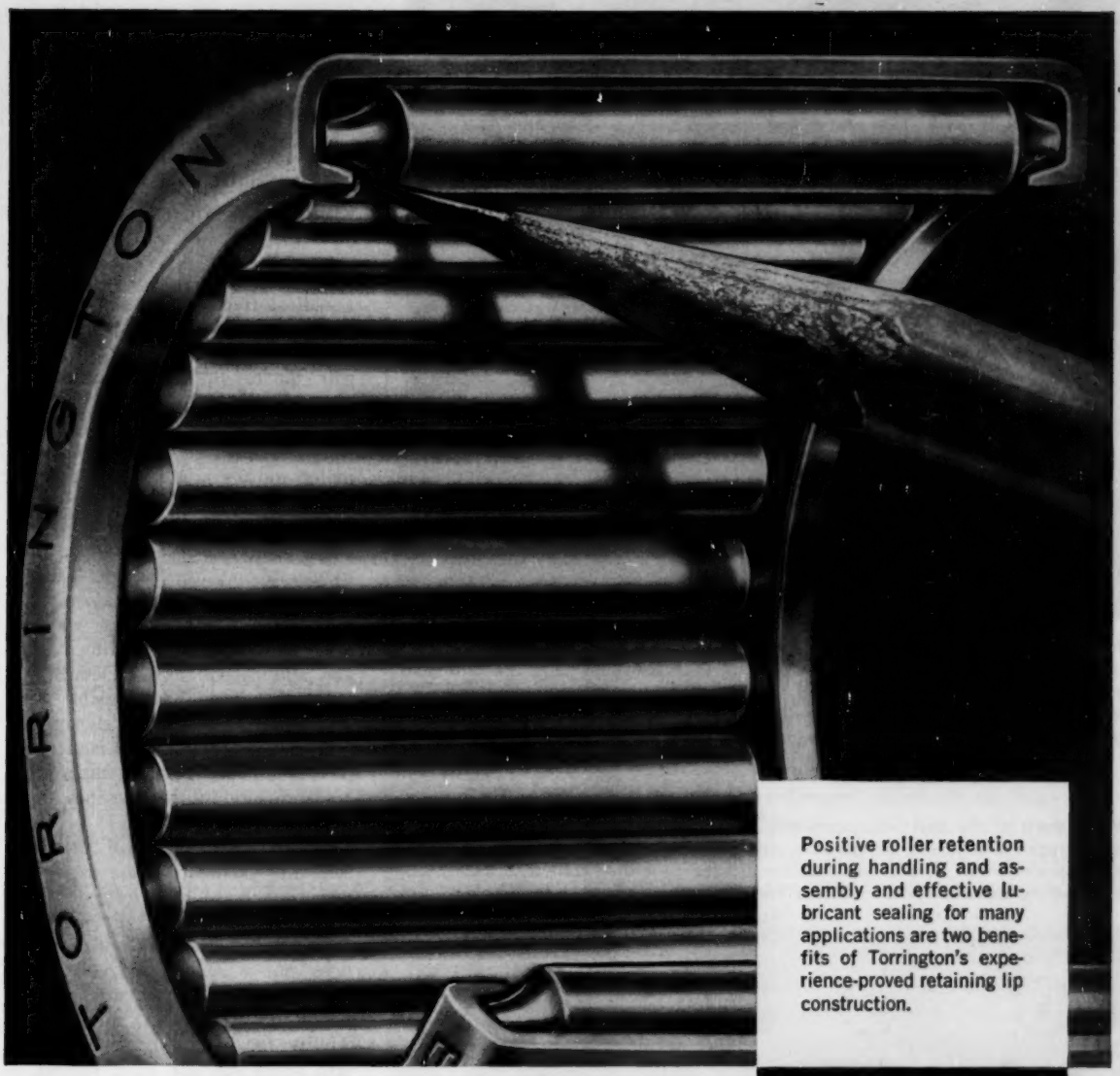
Attracting the best people into engineering teaching is becoming an increasingly thorny problem. Competition is severe, and Cornell, like other universities, finds it difficult to compete with the high salaries offered by industry to promising young engineering graduates.

Dean Corson offers this solution: "We can no longer include the view from the Library Slope in a man's salary and tell him it is worth $1000 per year. The universities which are going to remain strong are those which simply will not be outbid."



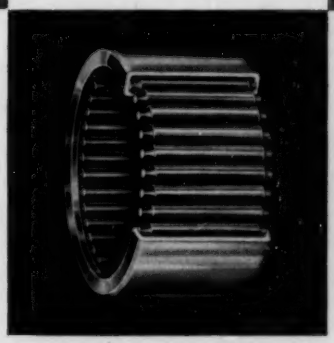
Push-Pull Lamp

New instrument lamp uses no metal base. Developed by General Electric Co., Cleveland, the all-glass lamp incorporates a wedge base that is easily inserted in a matching socket. Lighter and more able to resist high temperatures than metal-base lamps (because no basing cement is needed), the 12-v jellybean-size bulb is well suited for printed-circuit applications and for automobile dome and panel lighting.



Positive roller retention during handling and assembly and effective lubricant sealing for many applications are two benefits of Torrington's experience-proved retaining lip construction.

This little lip makes a big difference!



The turned-in lip at each end of Torrington Needle Bearings positively retains the trunnion - end rollers and makes the bearing truly a complete unit, with no possibility of roller fall-out.

This unit construction simplifies installation and servicing. The closely controlled clearance and the large area between cup lips and shaft form an effective labyrinth seal. Also this retaining lip allows pregreasing the bearing with the proper lubricant for each application.

Long experience with the Torrington Needle Bearing in thousands of applications has proved the merit of this and other features in efficient performance and long service life. Make sure *your* product benefits from the best that experience has to offer—specify Torrington Needle Bearings. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

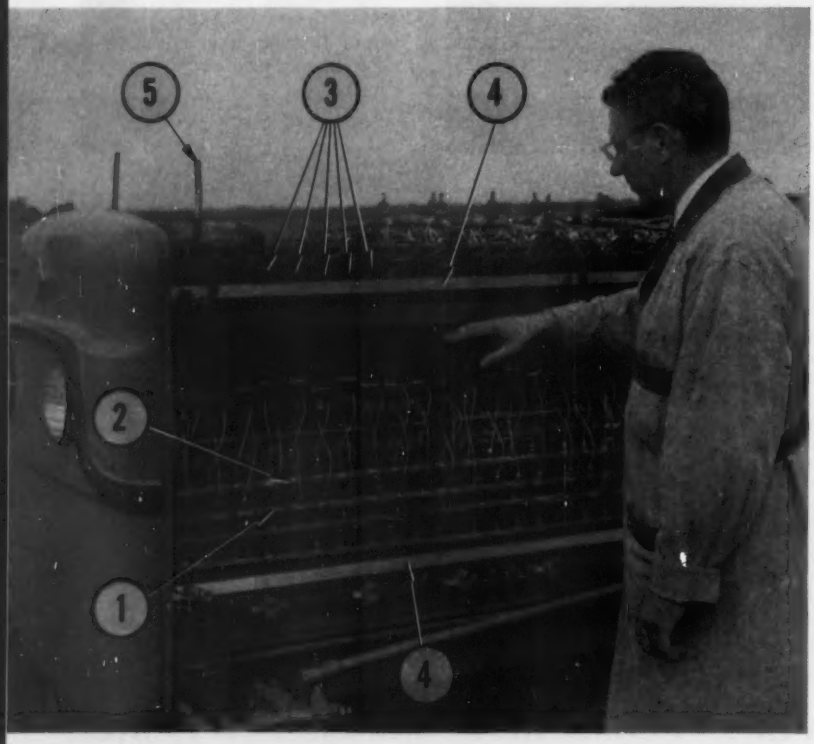
District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE ROLLERS • BALL • THRUST

Circle 410 on Page 19

Fuel cells that power the tractor supply 15 kw of electricity to a 20-hp direct-current motor. "Building block" power units, each with nine cells, are arranged in four banks that can be switched from series to parallel, furnishing a wide range of power outputs. For other applications, building block units can be added or taken away as necessary and any size power supply unit is possible.

Major parts of the fuel-cell system are: 1. Gas exhaust line. 2. Propane inlet line (oxygen inlet line is on the other side of the vehicle). 3. Nine-cell building block power units. 4. Bus bars that conduct the generated current to the motor. 5. Auxiliary exhaust system removes fuel gas if it is supplied too fast.



Fuel-Cell Debut:

Electric Tractor Runs on Propane

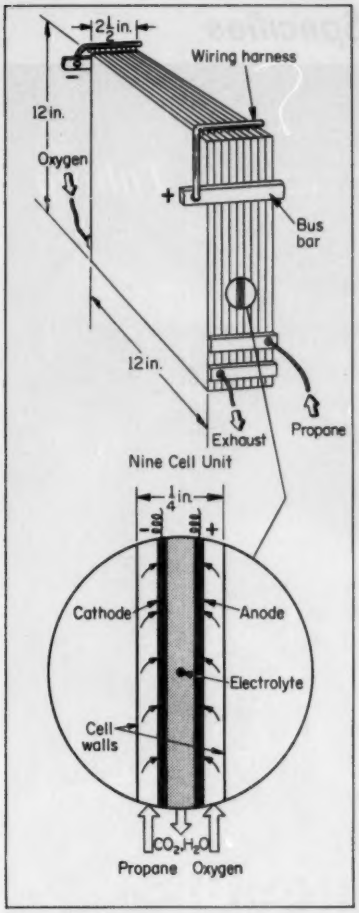
BUZZING like an electric razor, a radical tractor—powered by propane-fed fuel cells—has been plowing up fairways on a Milwaukee golf course. Built to illustrate how practical a source of power the new fuel cells are, the tractor harnesses 1008 cells to a 20-hp direct-current motor and exerts a 3000-lb drawbar pull on a plow.

Developed by Allis-Chalmers Mfg. Co., the new fuel cells are the first to operate on a low-cost fuel—either propane or natural gas. Company researchers have found a way to break down these gases into hydrogen and carbon ions. Details are still secret because of possible patents; however, company spokesmen will say that the trick is accomplished at atmospheric temperature and pressure in the presence of a catalyst.

Relative advantages of the fuel cell and the heat engine as power generators have been long debated. The fuel cell is generally accepted to be about twice as efficient—it does not depend on "heat sink" laws—and is now threatening the heat engine's main advantages: Ability to operate on cheap fuel, and small size for large output.

The tractor power plant is not excessively large, especially for a research vehicle: 1008 fuel cells (each measuring 12 x 12 x ¼ in.) supply 15 kw to the 20-hp motor. According to Dr. H. K. Ihrig, vice president and director of research, the cell is still in the research stage. Optimum cell size has yet to be determined. But since the cells can be mounted in every nook and cranny of a vehicle, waste space can be used to better advantage. Further, in the case of a stationary power supply unit, fuel is plentiful without storage tanks—the device can be connected to the local gas company's supply line.

The fuel-cell tractor, constructed as a demonstration unit, is not necessarily the best or the most obvious application, nor is it pres-



Fuel gas dissociates into hydrogen and carbon ions when it encounters the catalyst at the cathode. Electrons released travel via the external circuit to the anode where they are captured by oxygen molecules introduced from a separate source tank (oxygen from an air supply system is also sufficient). Battered by excess electrons, oxygen molecules become negative ions. In the electrolyte, hydrogen and carbon react with oxygen to form carbon dioxide and water vapor, the exhaust gases. The dry electrolyte permits cells to be mounted in any position.

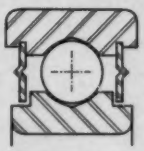
ently being considered as an addition to the A-C tractor line. "It was put together to show what could be done," says Dr. Ihrig, "and was never intended for production." Further refinements are necessary in the cell, and only little has been done to match the tractor to the powerplant. For example, conventional drive shafts and differentials could be eliminated and individual electric motors could be mounted at each drive wheel in a production prototype.

EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

PHOTO shows bearing ACTUAL SIZE

SECTIONAL DRAWING is 3 TIMES SIZE



SIZE: 10.500" OD; 0.270" wide; 0.250" thick.
BALL DIAMETER: 0.125" ±.000025".
MATERIALS: Stainless steel.
MAXIMUM RUNOUT OF OUTER RACE: 0.0002" TIR.
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.

Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example—

To save space, simplify assembly and prevent operating trouble, we designed and are producing this extra-thin-section ball bearing, equipped with a built-in shield on each side in place of separate shields. The shields fit so closely that they retain the lubricant and enable the bearing to pass the standard military sand and dust storm test. This construction assures long-lived low-torque operation, and cuts both assembly and maintenance costs.

YOUR design problem might likewise be simplified or your product improved by ball or roller bearings of special section or configuration, heat resistance, corrosion resistance, ultra precision, or other unusual properties. We design and produce such bearings to individual requirements, in any size from ¼" ID to over 70" OD; and we invite your inquiries.

FREE BULLETIN AFB-2 describes our work in this field—shows a wide variety of "specials"—tells about factors involved in special bearing applications. Write for it!

INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3689 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

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Automotive Power Steering Manufacturer Specifies

Cold drawing Ostuco tubing through precision ring die on cold draw bench at Shelby mill. Mandrel controls and sizes I.D.

"Automotive components are our business. We have produced literally millions. And we're still learning every day.

"One of the lessons we learned early in the game is that you can't beat Ostuco tubing for surface finish. It cuts our machining costs, keeps us on top competitively.

"There are other reasons, too, why Ostuco tubing tops our preferred list. We like its consistently close tolerances and unvarying quality, shipment after shipment. You might say we like its *product integrity* . . . "

To learn more about what Ostuco tubing can do for *your* production, contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.* AA-9431

OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
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430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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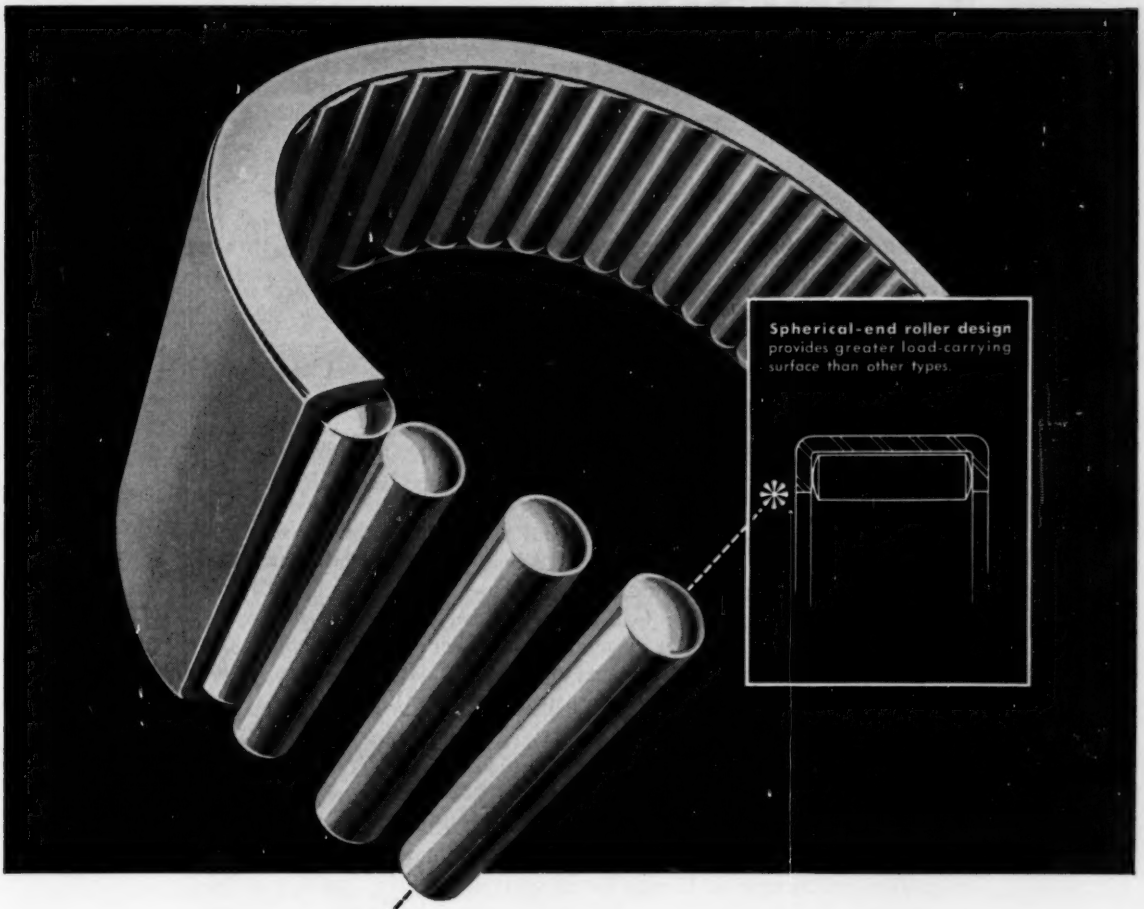

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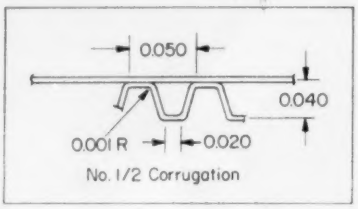
spotwelded foil makes open-face "sandwich"



Foil-gage structural panels, stiffened by miniature corrugations, may be the "high - temperature breakthrough" sought by airframe and missile designers, says Ryan Aeronautical Co. The single-sheet panels—called Mini-Wate—stand up under compression stresses exceeding 75 per cent of yield strength. Ryan builds the structure by resistance spotwelding foil-stock corrugations in a range of pitches to single sheets as thin as ¼ mil (0.00025 in.). Admitting earlier shortcomings of spotwelding for primary structures, Ryan attributes high fatigue life of Mini-Wate (over 10-million cycles) to the large number of lightly loaded welds. Other big advantages: 1. Wide range of available foil materials. 2. Simplicity of the spotwelding technique (compared to brazing). 3. No blind welds. 4. Low cost (lower than honeycomb sandwich panels, says Ryan).

diesel cabs qualify as true economy cars

Evaluation of diesel taxicabs in several major U. S. cities is beginning to produce some impressive figures. Six cabs operating in Los Angeles since June have averaged 26 mpg vs. 13 mpg for conventional models, according to Yellow Cab Co. Four of the cabs are Plymouths powered by Perkins P-4C diesels (4-cyl. 58 bhp @ 3000 rpm) and two are Mercedes 190-D sedans (4-cyl, 55 bhp @ 4000 rpm). While a significant improvement in fuel mileage was expected, the diesels came up with an unexpected trait: Their exhaust is much cleaner than that of their gasoline contemporaries—an especially welcome feature in smog-bound Los Angeles. The city's powerful Air Pollution Control District conducted a careful exhaust comparison covering all phases of cab operation (idle, cruise, acceleration, deceleration), found that the hydrocarbon content of diesel exhaust never exceeded 40 parts per million. Gasoline exhaust contained much more than this at idle, and poured out a blinding 5600 ppm during deceleration.

shooting season extended at Canaveral

Launching space probes from a "parking orbit" is NASA's newest scheme for extending the moon-shoot season at Cape Canaveral, home base for the Atlantic Missile range. Long eyed by missilemen as a means of increasing vehicle payloads, the parking-orbit technique circumvents the undesirable geographic location of Canaveral—now limited for lunar-probe launchings to the few days each month when the moon is at its most southernmost point. The parking-orbit plan is simple: Booster stages of a multistage vehicle hurl top stages into the start of an earth orbit at satellite speeds. When the orbiting vehicle is over the point on the earth's surface ideal for the start of a lunar mission—half or three-quarters around the earth from Canaveral—the top stage is fired and heads for the moon. Officials at Cal Tech's Jet Propulsion Lab—an NASA facility—anticipate that the parking orbit will boost payloads 20 per cent over those of direct-trajectory launchings.

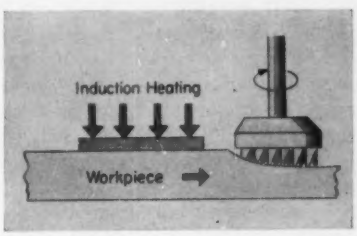
new stability for print-a-minute prints

Vital inspection and measurement details can be recorded on-the-spot with a new photo monitoring setup that uses Polaroid film. The new technique provides 4 by 5-in. dimensionally stable prints in 60 seconds. Direct measurements on film can be held to ±0.001 in., and magnification gives even better accuracy. Developed as a quality-control tool by Stocker & Yale Inc., Marblehead, Mass., the system also can be used for setting up and illustrating standards and specifications, as an aid in exchanging information between departments, and to provide service illustrations for field men.

plunger pumps: lighter, smaller, cheaper

Cavitation and vibration—long-standing limits on high-power plunger-pump performance—are under new attack. To exploit analytical and experimental results, BJ Service Inc., Long Beach, Calif., is testing a prototype 1000-hp triplex unit which gives 50 per cent more flow rate with only half the displacement of comparable old-style pumps. Performance gains are due chiefly to new, faster-acting valves, dynamic balancing of the crankshaft for smooth running at 1200 rpm. Looking ahead to an eventual factor-of-three improvement in pump-displacement utilization, chief design engineer, C. H. Rose, anticipates reversal of the trend toward larger, heavier, more expensive pumps.

machining the unmachinables



"Hot milling" may answer some of the difficult machining problems associated with ultrahard metals. A new process, developed by Cincinnati Milling Machine Co., uses induction heating to effectively soften the workpiece as it approaches the cutting head. Typical results: 4340 steel at 550 Bhn is milled at 550 sfpm (0.006 in. per tooth). Temperature at the cutting point is kept between 950 and 1000 F, and carbide tools are used. To get equivalent tool life by conventional cold milling, using steel tools, a speed of about 40 sfpm would be maximum.

transistors: made in Japan

Electronic Industries Association has adopted one way to answer Japanese competition in transistors: It's asking the Office of Civil & Defense Mobilization to investigate the imports. EIA predicts the "inevitable curtailment of future research and development." Without the continued civilian market, they contend that electronics companies will not be able to expand facilities to meet increasing military needs. A second (and more immediate) answer to the competition is also being tried. Texas Instruments Inc., Dallas, now offers transistors that sell for 50 cents each in some models. The new high-quality, low-cost series includes six types for entertainment applications (radio, TV, etc.) and ten types for industrial use. In comparison, a Japanese entertainment type transistor costs 80 cents, including 15 per cent import duty.

the '60s take the road

The survey of Detroit's new cars continues in this issue with a detailed inspection of the Valiant, and a look at the rest of Chrysler's line.

Overall, the '60 model year is conspicuous on several counts: First, of course, the small cars not only made their debut amid great fanfare, but with so much buyer enthusiasm that more compacts are scheduled to come. Mercury will introduce the Comet next spring, a car it already heralds as "the aristocrat of the economy cars." Buick, Oldsmobile, and Pontiac are strongly rumored to have compact versions in the works. "Informed sources" in Detroit further predict that several big names in autodom will either disappear or be coupled with the new small cars. For example, *Valiant* may become *Plymouth Valiant*, giving birth to a new line of cars with Valiant characteristics. The same mutation might combine the Edsel and the Comet.

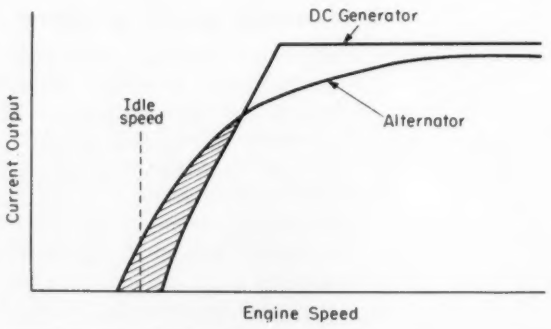
On the engineering front, 1960 marks an increased use of unitized bodies, not only in the compacts, but in larger cars such as Plymouth and DeSoto. The continual decline in horsepower is evident, except in the compacts where an edge on competitors is apparently sought. Two years ago, for example, Mercury offered a 400-hp engine; today the same engine delivers 310 hp—the difference being enough to power an economy car.

Accessories continue to come and go: Fuel injection is offered on only one '60 car (Corvette), and air suspension is practically extinct (Cadillac and Rambler). Self-adjusting brakes show an increase in popularity by sliding into the luxury-car class (Cadillac), and Chrysler, a pioneer in many new accessories, now boasts automatic swivel seats and power-operated door locks. Running away with honors for innovation are Chevrolet's Corvair (air-cooled rear engine and swing axle) and Chrysler's line (inclined engine, ram-induction manifolding, and the first ac generator tailored for an American passenger car).

An ac generator (alternator) powers Valiant's 12-v dc electrical system. Full-wave rectification is provided by six silicon-diode rectifiers mounted on the back of the alternator housing. Graph right, shows the alternator's big selling point: It delivers 10 amp at idle, where a dc generator has little or no output. Other factors favoring the alternator:

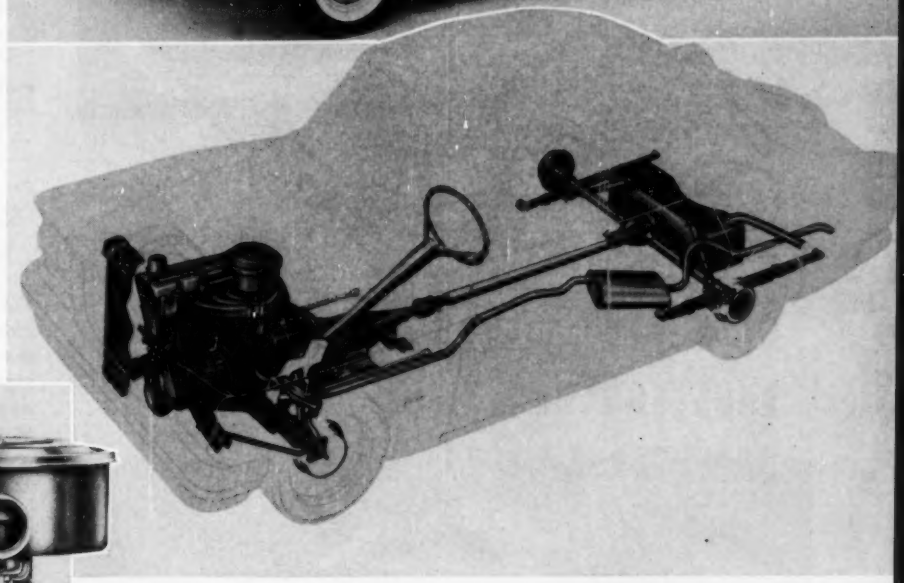
- No current regulator needed; alternator is self regulating.
- No cut-out needed; diodes prohibit reverse current flow.

This leaves just one external component—a simple voltage regulator. The alternator is also a big weight saver. It weighs 12 lb vs. about 20 lb for a dc generator. This is because of an aluminum housing, and because the field, which is the heavy cylindrical part of a dc generator, is the rotating member (and thus smaller) in an alternator.

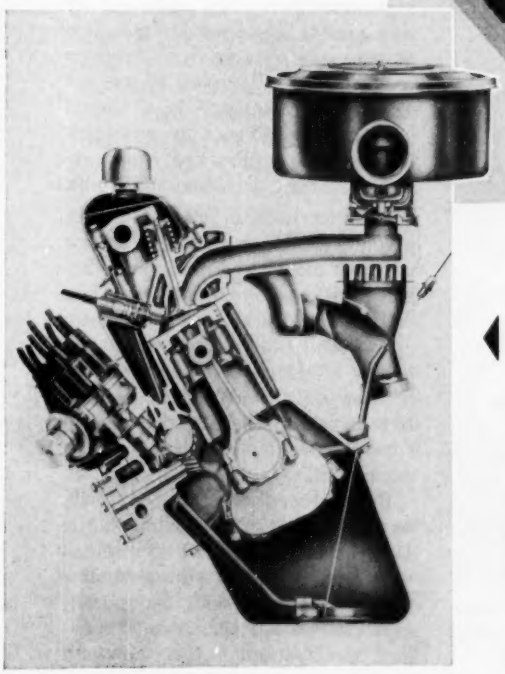


Valiant

Chrysler Corporation's rakish entry in the small-car field is produced in two series—V-100 and V-200—with a four-door sedan, two-seat wagon, and three-seat wagon in each series. Dimensions and engine specifications are the same for all models, trim and accessories making the difference. Optional equipment on all models includes automatic transmission, power brakes, power steering, radio, heater, and padded instrument panel.



Valiant's distinguishing mechanical traits include an inclined engine, torsion-bar front suspension, unitized body, and an ac generator.



Valiant's in-line engine is inclined 30 degrees from vertical, an unusual geometry that Chrysler chose for these reasons:

- Center of gravity is lowered, and so is hood height.
- Space is created for a new manifolding system and for mounting the water pump beside the engine. The latter arrangement effectively shortens engine length.

The special manifold, cast of aluminum, consists of six long, curved tubes leading to the individual cylinders from a single-throat downdraft carburetor. Exhaust manifold, mounted on the same side, has large-radius curves for minimum back pressure. A thermostatic heat-control valve directs heat to a stove beneath the carburetor to insure fast warm-up. The engine has wedge-type combustion chambers; valves are operated through solid tappets, tubular-steel pushrods, and stamped rocker arms. Self-locking screws in the rocker arms permit valve-lash adjustment. Engine weight has been minimized by careful foundry techniques to reduce section thickness, and by the use of numerous aluminum parts, e.g., pistons, intake manifold, distributor housing, water-pump housing, and water-outlet elbow.

Imperial Custom four-door Southampton

Chrysler New Yorker four-door hardtop

Imperial

The top car at Chrysler has been restyled right down to the steering wheel (it's elliptical this year, for a better view of the instrument panel). A view of the impressive panel at night reveals the soft new glow of electroluminescence—a feature pioneered on Chrysler cars this year. While the driver admires the novel EL light source, a new "educated" autopilot will monitor his speed. This year, the autopilot doesn't have to be reset after each brake application; it re-engages automatically when the dialed speed is reattained. And the driver will probably be more comfortable, too —a new "high-tower" driver's seat encourages a relaxed, head-back attitude.

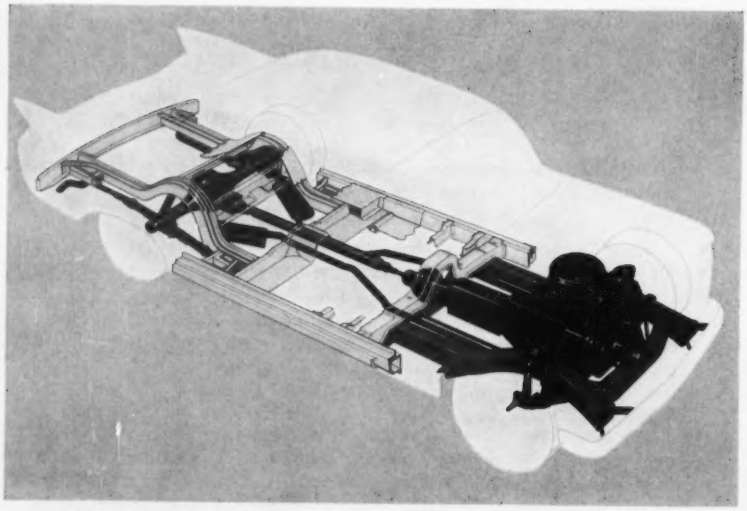
In more basic mechanics, Imperial is about the same as last year.

Chrysler

Beginning with Chrysler, and down through the line, including Valiant, Chrysler Corp. has adopted unit-body construction. The company claims a 100 per cent improvement in rigidity and a 40 per cent gain in beam strength over separate-chassis models from previous years. Door pillars and hinges are also much stronger, which should help cure misalignment problems. Fenders and grilles are easily removed, cutting accident repair bills.

Chrysler uses an elaborate rustproofing process in building the new unitized models. The process begins with the raw steel entering the plant, and ends in several body-dip operations. Sound proofing the bodies is also a careful procedure, because unit construction, particularly in larger cars, can give a noisy "drum" effect in the passenger compartment.

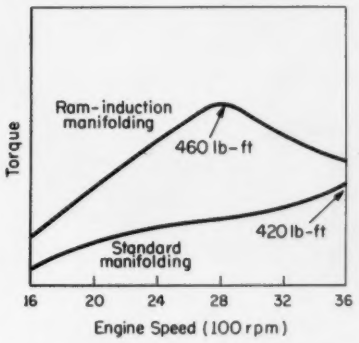
Body dimensions are relatively unchanged for '60 (wheelbase is the same as last year), but styling has been heavily redone, patterned after the famous 300 Series. No significant change has been made in engine specifications.



All Chrysler cars except Imperial now have unitized bodies. Lower body shell (light gray) is bolted to a heavy front structure (dark gray) which supports the engine and front suspension (black).

DeSoto

Beginning with DeSoto, and down through Dodge, Dart, and Plymouth, Chrysler introduces another new design feature: Ram-induction manifolding. Packaged as an engine option, the "silent supercharging system" is effective at medium and high speeds, giving the engine a moderate boost in power. The principle is not new, but this is its debut in passenger cars.



Torque peaks at lower rpm with ram-induction manifolding. (Expanded plot)

DeSoto's standard engine specifications are largely unchanged. Body dimensions are also about the same as last year, except that with the adoption of unitized construction, DeSoto has dropped the 126-in. wheelbase used on last year's Firedome and Fireflite models and builds all '60 cars (Adventurers and Fireflites) on a 122-in. wheelbase.

Dodge and Dart

Dodge this year has rearranged its lineup to make room for 20 new models under the Dart label. These are segregated under three series: Seneca, Pioneer, and Phoenix. The regular Dodge is still around, with two new calling cards: Matador is the top of the line, Polara a shade below it.

Comparing Darts to Dodges, mechanically: Dart has 2-in. shorter wheelbase and is 4 in. shorter overall; both cars have unitized bodies. Dart is available with one option, however, that Dodge can't claim: A

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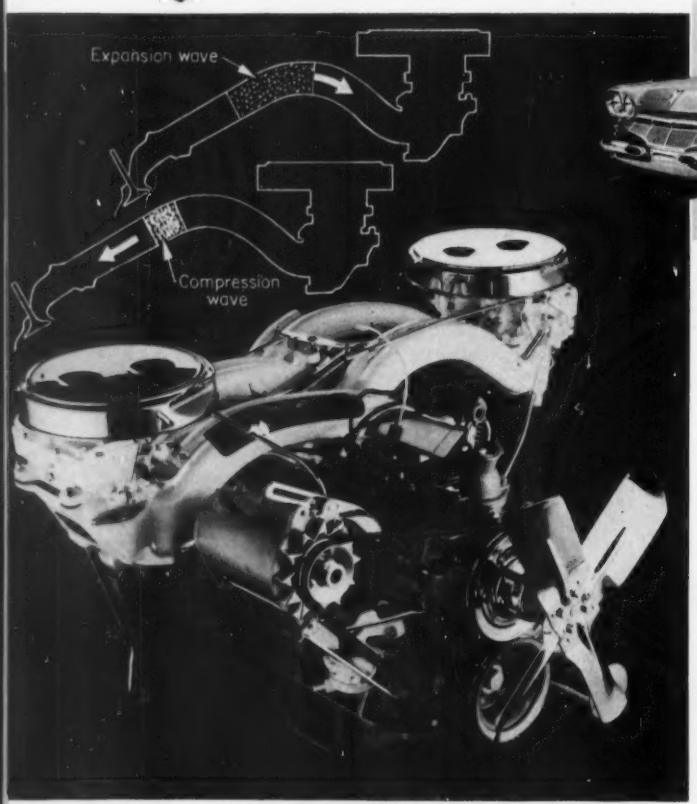
DeSoto Adventurer four-door sedan

Dodge Polara four-door sedan

Ram-induction manifolding uses two outboard-mounted, four-barrel carburetors feeding opposite banks. Carburetors are connected to intake manifolds through 30-in. rectangular pipes. When the intake valve opens in any one cylinder, a low-pressure condition is created as air and fuel begin to move into the combustion chamber. This creates an expansion wave which travels through the manifold to the mouth of the carburetor where it is reflected back toward the cylinder as a positive pressure pulse. When the pulse reaches the intake valve, it rams the fuel-air mixture into the cylinder. In effect, the tuned manifolds improve engine volumetric efficiency.



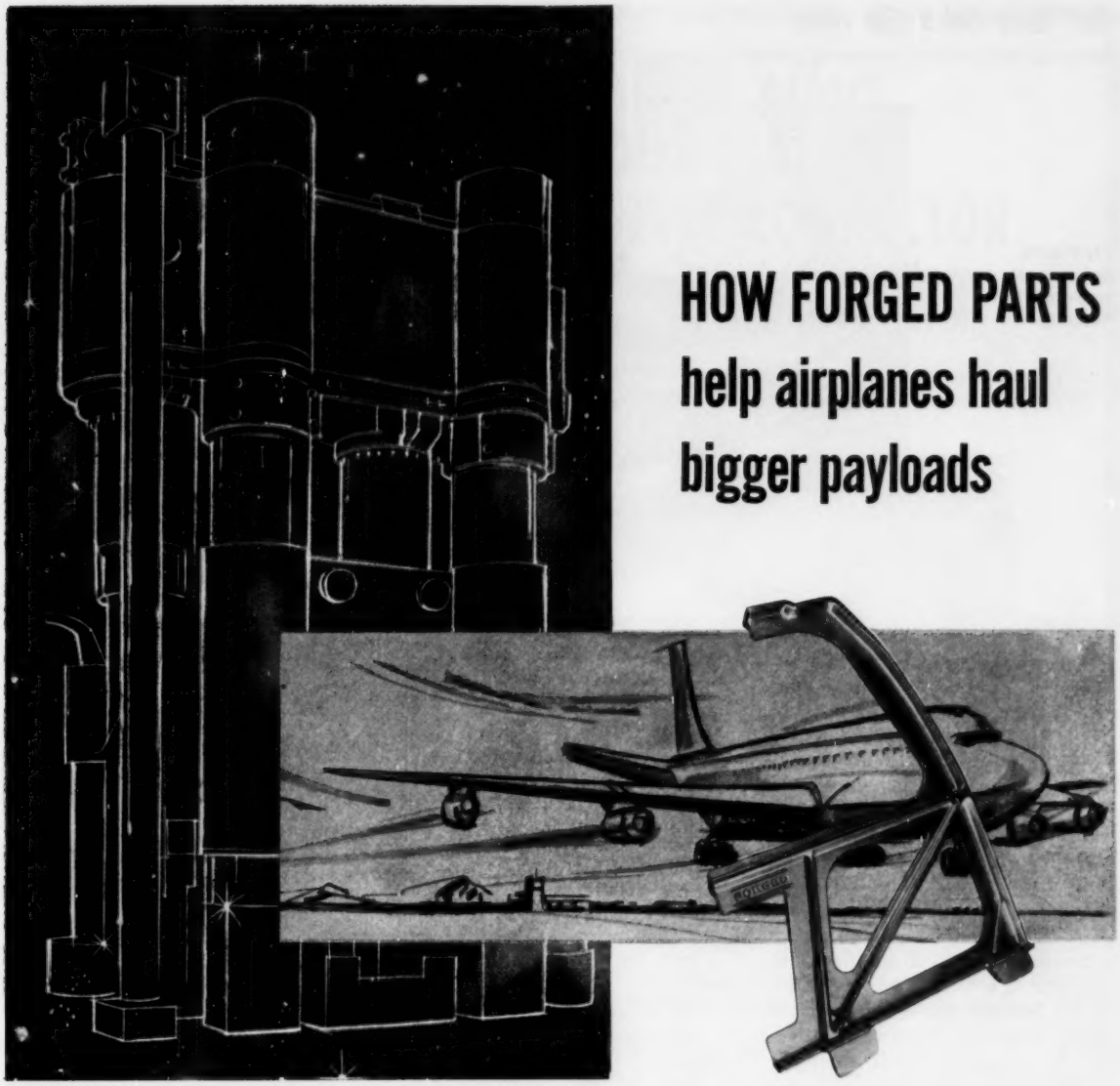
Dodge Dart two-door hardtop

new 225 cu-in. "Slant" six-cylinder engine. Similar to Valiant's engine, the Dart powerplant inclines 30 degrees to the right, has long curved tubes comprising the intake manifold, and a water pump mounted beside the engine. Ram-manifold V-8s are available in both Dodges and Darts.

Plymouth

Plymouth's wide selection of powerplants is expanded this year to include a ram-induction V-8 and the new Slant Six. Standard engine specifications are largely unchanged, and the car's unitized body retains last year's dimensions.

In the optional-item category,



HOW FORGED PARTS help airplanes haul bigger payloads

In an airliner, every pound of weight saved is worth hundreds of dollars . . . in revenue-making payload. And in military aircraft, pounds saved mean added miles-per-hour . . . or added load carried.

In commercial products . . . trucks, cars, materials-handling equipment . . . the pounds of dead weight you eliminate by using forgings make money year-after-year for the operator. The forging process lets you put the metal exactly where you need it to carry the load, withstand shock or vibration, endure torsion. And with not a surplus ounce of non-working weight going along just for the ride.

Forged parts are the designer's friend . . . strong where strength is needed, lowest in weight, twice-worked by original rolling of the best metals *plus* the hammer blows or high pressures of the forging process.

Write for literature to help you specify, design, and procure forged parts.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

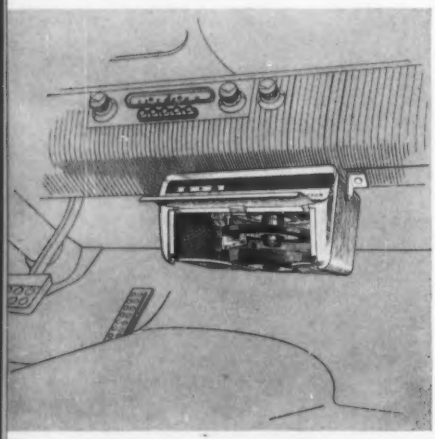
Names of sponsoring companies on request to this magazine

Circle 415 on Page 19

Plymouth Belvedere two-door hardtop

Plymouth probably wins the prize. It can be equipped almost like an Imperial. A new Safe-T-Matic door lock system automatically locks all doors when the engine is started—a handy feature in roll-over collisions. The doors remain locked until they are opened from the inside, unlocked from the outside with a key, or released by a lever on the instrument panel. The system is vacuum actuated, making it impossible to lock keys inside the car.

Another new item on Plymouth this year is a 45-rpm record player. It fits beneath the dashboard and plays 14 records (2 hr) consecutively. As a finishing touch, the glove compartment door has been designed to serve as a snack tray.



'60 Engines

Make and Model	Bore & Stroke (in.)	Displacement (cu in.)	Compression Ratio	Power, max (bhp)	Torque, max (lb-ft)	Carburetion
IMPERIAL	4.18 x 3.75	413	10:1	350 @ 4600	470 @ 2800	4b
CHRYSLER						
Windsor	4.03 x 3.75	383	10:1	305 @ 4600	410 @ 2400	2b
Saratoga	4.03 x 3.75	383	10:1	325 @ 4600	425 @ 2800	4b
New Yorker	4.18 x 3.75	413	10:1	350 @ 4600	470 @ 2800	4b
DESOTO						
Firedlite	4.12 x 3.38	361	10:1	295 @ 4600	390 @ 2400	2b
Adventurer	4.25 x 3.38	383	10:1	305 @ 4600	410 @ 2400	2b
(Power Pak)	4.25 x 3.38	383	10:1	325 @ 4600	435 @ 2800	4b
(Ram Manifold)	4.25 x 3.38	383	10:1	330 @ 4800	460 @ 2800	Two 4b
DODGE						
Matador	4.12 x 3.38	361	10:1	295 @ 4600	390 @ 2400	2b
Polara	4.25 x 3.38	383	10:1	325 @ 4600	425 @ 2800	4b
(Ram Manifold)	4.25 x 3.38	383	10:1	330 @ 4800	460 @ 2800	Two 4b
DART						
"Slant Six"	3.40 x 4.12	225	8.5:1	145 @ 4000	215 @ 2800	1b
V-8 Options	3.91 x 3.31	318	9:1	230 @ 4400	340 @ 2400	2b
	3.91 x 3.31	318	9:1	255 @ 4400	345 @ 2800	4b
(Ram Manifold)	4.12 x 3.38	361	10:1	310 @ 4800	435 @ 2800	Two 4b
PLYMOUTH						
Savoy, Belvedere	3.40 x 4.12	225	8.5:1	145 @ 4000	215 @ 2800	1b
Fury	3.91 x 3.31	318	9:1	230 @ 4400	340 @ 2400	2b
Options	3.91 x 3.31	318	9:1	260 @ 4400	345 @ 2800	4b
	4.12 x 3.38	361	10:1	305 @ 4800	395 @ 3000	4b
	4.12 x 3.38	361	10:1	310 @ 4800	435 @ 2800	Two 4b
	4.25 x 3.38	383	10:1	330 @ 4800	460 @ 2800	Two 4b
VALIANT	3.40 x 3.12	170	8.5:1	.....	.....	1b

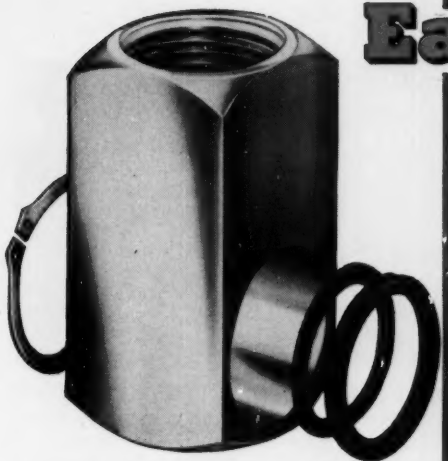
'60 Sizes

Make and Model*	Wheelbase (in.)	Length (in.)	Width (in.)	Height† (in.)
IMPERIAL	129	226.3	80.1	56.7
CHRYSLER				
Windsor	122	215.4	79.4	54.9
Saratoga, N. Yorker	126	219.6	79.4	55.6
DESOTO	122	215.4	79.4	55
DODGE	122	212.6	78	54.9
DART	118	208.6	78	54.8
PLYMOUTH	118	209.4	78.6	54.6
VALIANT	106.5	184	70.4	53.3

*Four-door sedan. †With five-passenger load.

Eastman offers INDUSTRIAL SWIVEL CONNECTOR

to eliminate hydraulic hose failure under severe flexing



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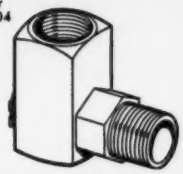
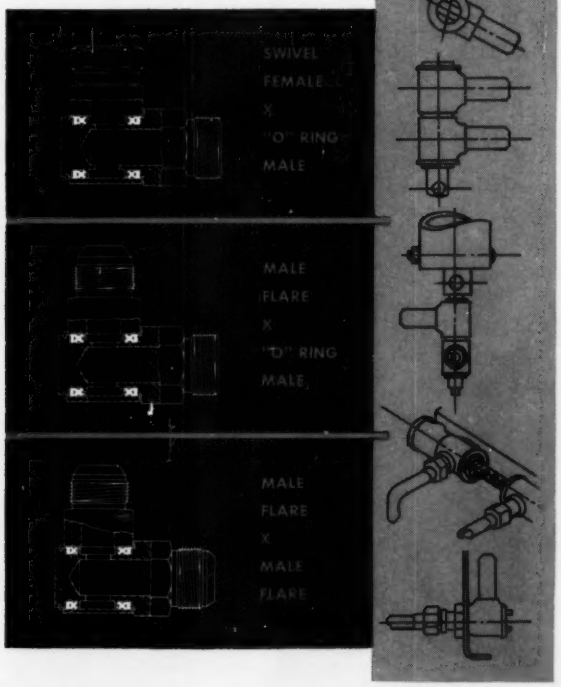
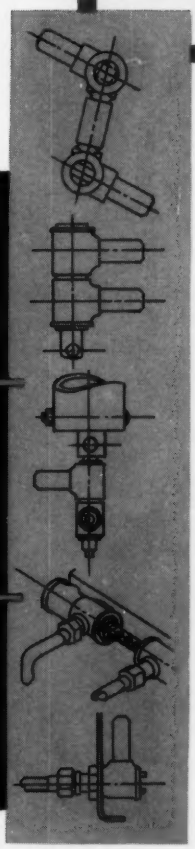






If you have been designing "around" metal swivel joints because of high cost, EASTMAN now offers an economical swivel connector for industrial use—precision engineered to assure adequate freedom of motion—proved under the most rigid government requirements.

Unique design assures "balanced" flow of hydraulic fluid at required pressure—at any angle. Fluid pressure is also balanced by a ***double seal*** assembly at each end of stem. Pressure-Balance assures equal internal pressure, causing the body to float about the stem, free of end load and friction.

Eastman Swivel connectors will make your flexing installations the most reliable link in your Hydraulic Assembly.

APPLICATIONS:
For use on Cranes, Loaders, Earth Moving Equipment, Hydraulic Presses, Shears, etc.—wherever unusual flexing and exposure may shorten hose life or cause premature failure and frequent replacement.

ECONOMY:
Permits use of shorter hose lengths since less hose allowance is needed for complete extension. Shorter lengths of longer lasting, multiple spiral wire high pressure hose may be used, since Swivel Connector absorbs flexing motion.

ADAPTABILITY:
Body of Connector available with any combination of ends. Now available in types and sizes shown at left. Various combinations of stems can be interchanged with any body style.

WRITE, WIRE or CALL about Eastman Swivel Connector Opportunities in Your Line.

STANDARD SIZES AND COMBINATIONS AVAILABLE

●

LOW TORQUE—Freedom from friction, even under high pressure.

WIDE RANGE—Operating pressures up to 5000 PSI. Trouble-free operation through wide temperature range.

ROTATION—Full 360° for all manifolds.

SIZES—Steel, plated for corrosion protection—½" thru 1½".

Eastman
first in the field **MANUFACTURING COMPANY**
Dept. MD-10, MANITOWOC, WISCONSIN

SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

Circle 416 on Page 19

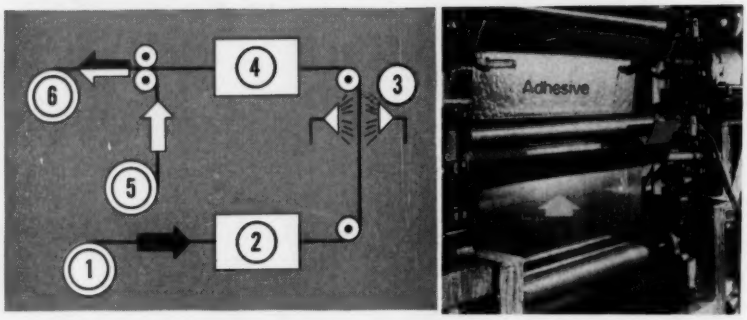
New Process Cuts Cost of Plastic-Coated Steel

Coils Now Available, New Uses Predicted

ALLENTOWN, PA. — Because they could be bonded only to cut sheets of steel, decorative plastic coatings have not yet found use in all their potential applications. Cut sheets involve costly handling and material waste. However, a new process for bonding the coatings to coil steel promises to revise this situation.

Developed by Enamelstrip Corp., subsidiary of National Steel, Pittsburgh, the technique will permit end-product manufacturers to feed continuous plastic-coated coils into their fabricating equipment. This eliminates hand feeding, broadens applications, and cuts costs. No changes in existing tooling are required, for despite being predecorated, the steel can be put through the same forming operations as noncoated steel.

The steel can be decorated in any pattern that can be photographed, and the surface is protected by a full thickness of transparent, polyester plastic coating. Tests of the coating in a 0.0003-in. thickness prove it ten times more abrasion resistant than materials now used on tables, cabinets, and counter tops.

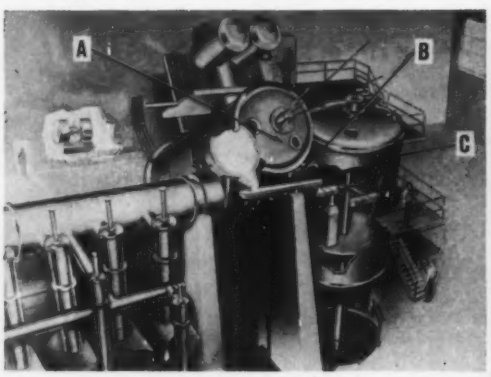


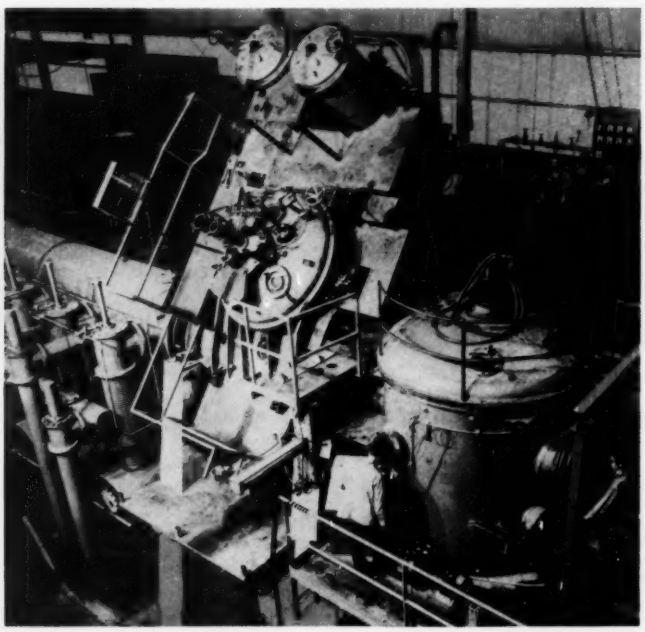
Steel from coils up to 2 miles long (1) enters a preparation area (2) where it is bathed in alkali cleaner, hot water, metal-treating spray, room-temperature water, and chromic acid. It is then dried and preheated. Before the metal enters a curing oven, a coating is applied to both sides (3, and right). The decorative side is coated with an adhesive, the reverse side with a protective or protective-decorative coating. As it comes out of the curing oven (4), the protective coating is "dry" and the adhesive is "tacky." Film from the roll of plastic (5) has been preheated and is now fed to the tacky side of the metal. The combination is quick-chilled and rolled ready for shipment (6).

In the older, cut-sheet coating process the clear-plastic film is underprinted and then backed with a colored base coat. The printing (the base coat) is adhesive-bonded to the sheet metal.

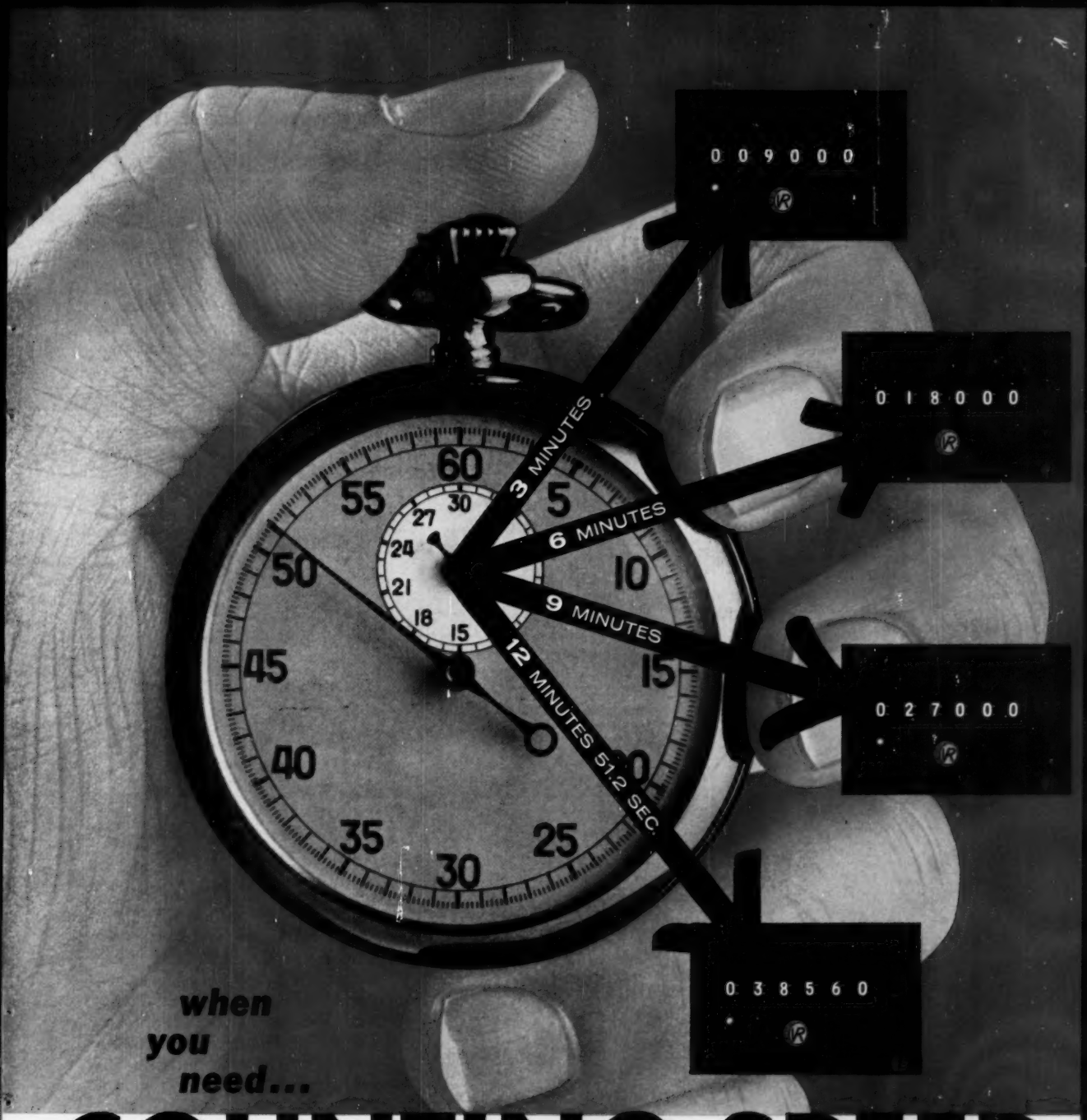
In the new enamelstrip process, an unbacked and printed clear plastic is used. Pigment is simply added to the adhesive, eliminating both a material and a procedure. Coating can be applied to only one side of the coil or both sides at once, and the two sides can be different colors. The process offers the added advantage of thermosetting, rather than thermo plastics, which soften at moderate temperatures.

Tilting Furnace Solves Vacuum-Cast Shortage





Abundance of vacuum-cast metals needed for high-temperature applications is assured by a tilting arc furnace installed for the Kelsey-Hayes Co., New Hartford, N. Y., by ASEA, Vastras, Sweden. Melting chamber (A) rotates to tilt crucible. Tundish (B) transfers melt to mold chamber (C). Ingots from the new furnace range in weight from 200 to 5000 lb. Kelsey-Hayes' Metals Div. now claims a vacuum-cast capacity of one million pounds per month.



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Specify VEEDER-ROOT No. 1591 Quick Reset, High Speed Magnetic Counter

The No. 1591 resets to zero with the flick of a finger with manual reset, or in one second with electrical reset.

The No. 1591 is designed for accurate, dependable remote indication of machine operation, or for counting articles at high speed. Speed is 3000 counts per minute, 4 or 6 figures, manual or electrical reset, and made for panel mounting. Maximum panel area required is: 1.7" x 2.1" for four figures and 1.7" x 2.8" for six figures. The 1591 is *available from stock.*

Send for Veeder-Root Technical Information. Complete catalog data will be sent to you at once and application assistance is available from a Veeder-Root Counting Engineer if desired. Write or call today.

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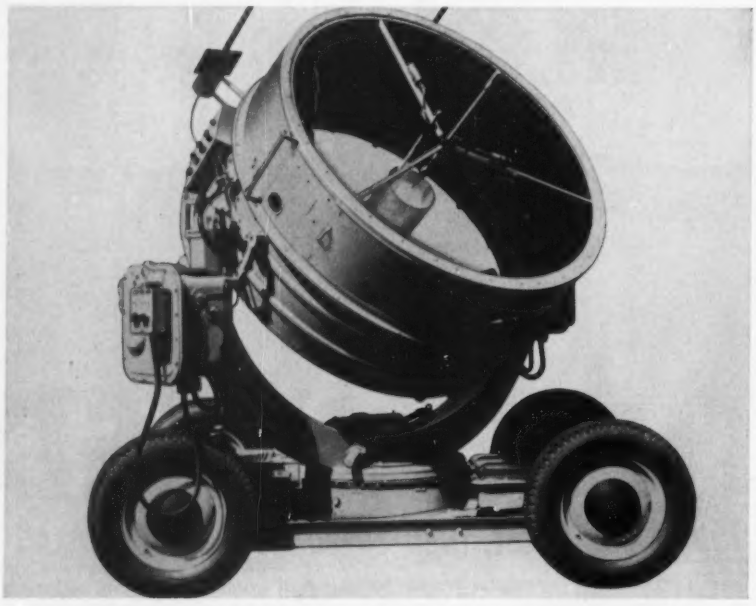
Circle 418 on Page 19

Rifle Makes Infantryman an Antitank Weapon

New 90-mm shoulder-fired recoilless rifle gives the foot-soldier close-range firepower equal to that of a medium-sized tank. The rifle fires a shaped-charge shell capable of penetrating the heaviest armor. Its effective range is 500 yards—more than twice that of the 3.5-in. bazooka used in the Korean War. Muzzle velocity is less than that of a revolver. Recoil is eliminated by exhausting gases through a nozzle at the rear of the rifle. Designed for use by a two-man team, the 35-lb, 4-ft long weapon can be carried, loaded and fired by one man if necessary. Design, engineering, and direction of system development were carried out at the Army Ordnance Corps' Frankford Arsenal, Philadelphia.



Build-It-Yourself: 6741 F

Solar furnace kit designed by Waltham Precision Instrument Co., Thermal Dynamic Products Div., Waltham, Mass., builds a furnace able to create temperatures to 6741 F and heat fluxes to 365 cal per sq cm per sec. The assembled unit is a 60-in. diam furnace on a mobile or stationary platform, fully equipped with an automatic tracking system, a remote controlled sample positioner and temperature adjustment, and a power supply. Assembled unit costs $4875; a kit, $2975.

Water Spray Cools Radar On Hypersonic Aircraft

SAN DIEGO, CALIF.—New cooling system being developed by Convair Div., General Dynamics Corp., is designed to prevent airborne radar from burning up in hypersonic flight.

In subsonic flight, ram air is used for electronic component cooling. As speed picks up and inlet air reaches 120 F, the Convair cooler adds water spray and decreases the flow of ram air. At Mach 2 (inlet temperatures about 300 F), the cooler cuts out ram air and increases the water spray. Water boiled off the hot equipment is released as steam.

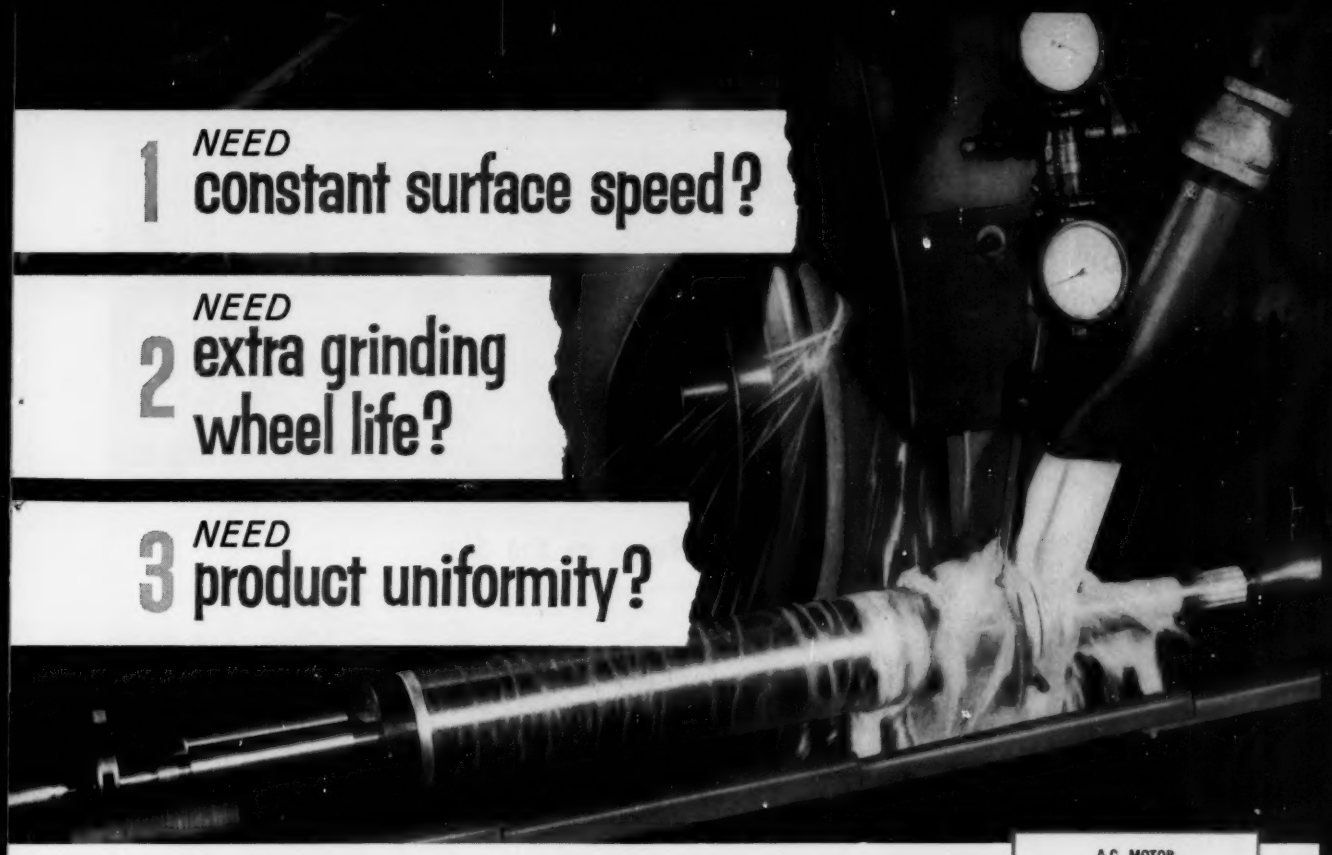
The unit is being tested at simulated altitudes up to 75,000 ft and speeds of Mach 3.2 for 15-min periods. At these extremes, aircraft intake air temperatures reach about 650 F. The cooler stores one gallon of water for use during the 15-min critical speed and temperature period.

Silent Service Looks for Quiet Nuclear Powerplants

Second Generation Reactors Get Rid of Coolant Pumps

SCHENECTADY, N. Y.—A new Navy project will lead to development of a prototype nuclear reactor that depends on natural circulation of the coolant. Simpler and quieter, the system will avoid coolant pumps and associated valves, piping, and electric generating and control equipment, and will increase operating reliability of atomic submarines.

The project, contracted to the General Electric operated Knolls Atomic Power Laboratory, should lead to a "second generation reactor," expected to perform better than any earlier submarine reactors. Maintenance problems will be reduced and breakdown possibilities will be narrowed by elimination of equipment necessary to force circulation of coolant. In addition, since it will be quieter, a submarine having this type reactor can better escape detection by supersensitive listening devices on enemy antisub vessels.



1 NEED constant surface speed?

2 NEED extra grinding wheel life?

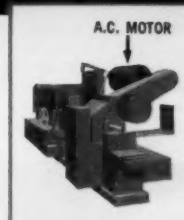
3 NEED product uniformity?

you get all three with...

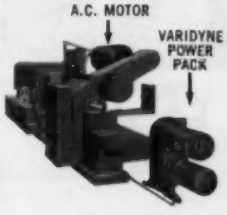
U.S. VARIDYNE GRINDER CONTROL

It is now possible to adjust grinding wheel speed on a cylindrical grinder *automatically.* The U.S. VARIDYNE GRINDER CONTROL provides controlled frequency of A.C. electric power and can, thus, convert your standard, A.C. grinding wheel motor into a variable speed drive. This results in: (1) CONSTANT SURFACE SPEED—or peripheral speed which is accomplished by varying the wheel speed according to wheel diameter. This eliminates downtime for pulley changes and provides optimum cutting speeds. (2) EXTRA GRINDING WHEEL LIFE—infinite adjustment and correct operating speeds mean fewer wheel dresses, less wear, and better use of wheel at extreme diameters. (3) PRODUCT UNIFORMITY—automatic control of wheel-to-work speed insures uniform finish regardless of wheel wear. Because of adjustable wheel speed feature, you can handle more materials with the same grinder and often without wheel changes. VARIDYNE makes your grinder more versatile. In addition, there is no danger of overspeed through loss of D.C. motor field as only A.C. motors are used.

VARIDYNE GRINDER CONTROL is another example of how Industry is using standard A.C. motors for variable speeds through the use of VARIDYNE. Your U.S. Motors representative will be glad to show you how VARIDYNE will solve your production problems. Call or write today.



BEFORE INSTALLING VARIDYNE, grinding speed changed as wheel circumference wore down.



WITH VARIDYNE, wheel wear is compensated by increasing rpm, maintaining constant grinding speed.

U.S. ELECTRICAL MOTORS INC.

P. O. BOX 2058, LOS ANGELES 54, CALIFORNIA
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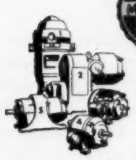

U.S. MAJOR MOTOR LINES INCLUDE:
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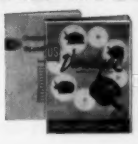


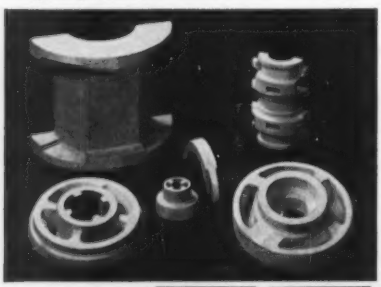
FREE ILLUSTRATED BROCHURES ...for complete information send for FREE *Varidyne Bulletin No. F-1910 and Controlled Speed System Bulletin No. F-1952.*

Circle 419 on Page 19

"User Reports" prove . . . BEARIUM METAL out-performs . . . wears longer than all other types of bearing materials.

BEARIUM METAL'S amazing superiority is due to the uniform dispersion of microscopic lead particles within the copper-tin grains rather than between the grain boundaries as found in ordinary bronzes. Result is that it will not seize or score the shaft nor will it melt out like babbitt—even in applications where a liquid other than oil must be used as the lubricant.

If you have a bearing application calling for dependable, trouble-free performance, by all means BEARIUM METAL *is your best buy in bearing bronze.* Try it on one of your toughest jobs. You'll be glad you did!



BEARIUM

Bearium Metal

Ordinary Leaded Bronze

FEATURES: Non-Seizing and Non-Scoring • Long-Wearing • Self-Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, Uniform Structure.

AVAILABLE IN: cored and solid bars, centerless ground rods, machined parts, pattern castings.

Write for the BEARIUM METAL *story.*

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NEVIN ENGINEERING ASSOCIATES
PACIFIC PALISADES, CALIF.
In Canada:
BEARIUM METALS OF CANADA, LTD.
RICHMOND HILL, ONT.

Circle 420 on Page 19

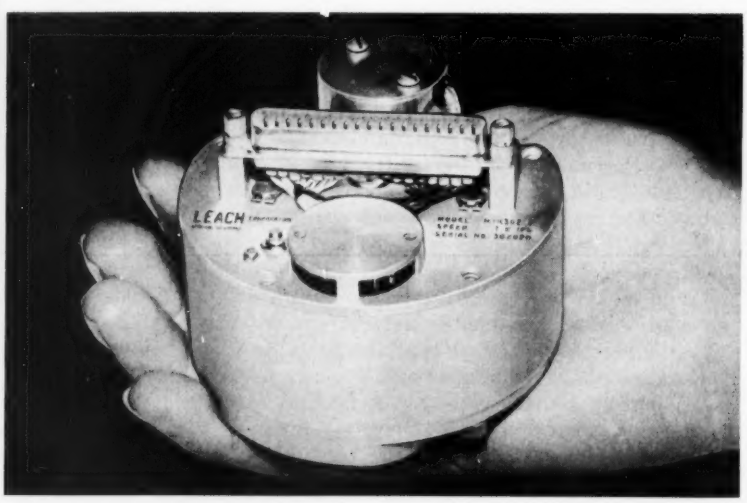
Conference Room in the Sky

Airliner comfort is designed into the new Beechcraft six-passenger Queen Air. Intended for executive transportation, the airplane's conference-room cabin features deep-cushioned reclining seats, sound-absorbing carpeting, large panoramic windows, and a fold-away work table (along with air conditioning and other more standard equipment). Twin 340-hp Lycoming supercharged, fuel-injection engines get both the 4740-lb aircraft and its 2960-lb maximum useful load off the ground and over a 50-ft obstacle in 1560 ft. Landing distance over the obstacle is 1685 ft. Model 65 is fully instrumented for all-weather operation and is designed to accommodate the latest electronic equipment—including weather-avoidance radar. Production of the $120,000 plane is scheduled for early 1960.

Queen Air Performance*

Cruising speed (70% power, 15,200 ft)	214 mph
Top speed (12,000 ft)	239 mph
Stalling speed (gear and flaps down)	85 mph
Rate of climb (sea level)	
two engines	1300 fpm
one engine	180 fpm
Absolute ceiling	
two engines	28,500 ft
one engine	13,000 ft
Maximum range (45% power, 15,000 ft)	1590 miles

*Maximum gross weight



Tiny Tape Recorders

World's smallest tape recorder will soon be joined by an even smaller brother. The one pictured weighs 24 oz and records data on 14 channels at tape speeds ranging from ¼ to 15 ips. The smaller version, soon to go into production, will weigh only 10½ oz (with tape), measure 2½ in. diam by 3¼ in. long, and will record data on 28 channels at tape speeds from 0.469 to 60 ips. Developed by Leach Corp., Los Angeles, the recorders will survive extreme shock and vibration conditions and will operate in a temperature range of −50 to 200 F.

Circle 421 on Page 19→

THIS IS CRONAFLEX® DRAFTING FILM (.004" THICKNESS)

WRITE ON IT · ERASE IT · TRACE THE DRAWING
TEST TRANSPARENCY · NOTE GLARE RESISTANCE · TEAR IT—IF YOU CAN!

THIS IS ONE COUPON YOU CAN'T TEAR OUT.
BETTER USE SCISSORS OR A KNIFE.

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Wilmington 98, Delaware.

Printed in U. S. A.

E. I. du Pont de Nemours & Co. (Inc.)
Photo Products Department
2432-A Nemours Building, Wilmington 98, Delaware

Please send me additional information about CRONAFLEX Drafting Film and a list of suppliers in my vicinity.

Name_____

Title_____

Company_____

Street_____

City_____ Zone_____ State_____

THIS IS CRONAFLEX® DRAFTING FILM (.004" THICKNESS)

WRITE ON IT · ERASE IT · TRACE THE DRAWING

TEST TRANSPARENCY · NOTE GLARE RESISTANCE · TEAR IT—IF YOU CAN!

E. I. du Pont de Nemours & Co. (Inc.)
Photo Products Department
2432-A Nemours Building, Wilmington 98, Delaware

Please send me additional information about CRONAFLEX Drafting Film and a list of suppliers in my vicinity.

Name _____

Title _____

Company _____

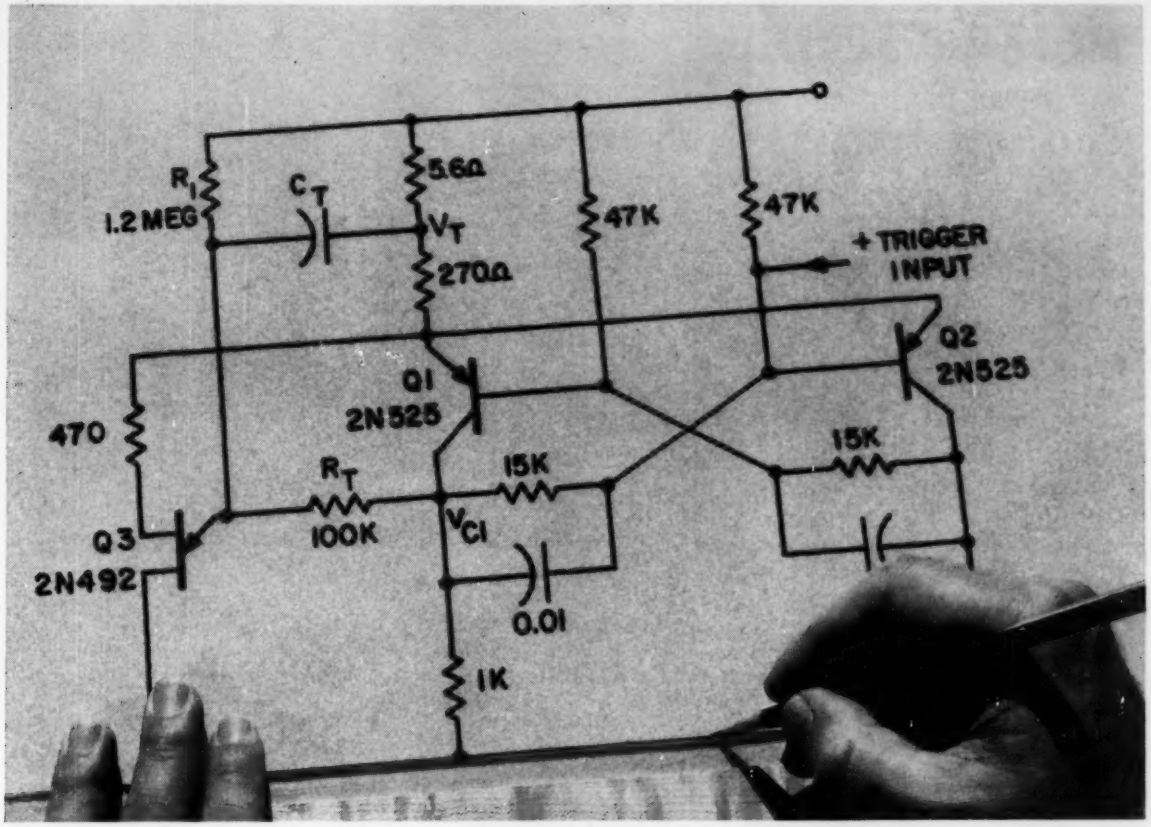
Street _____

City _____ Zone _____ State _____

THIS IS ONE COUPON YOU CAN'T TEAR OUT.
BETTER USE SCISSORS OR A KNIFE.

CRONAFLEX Drafting Film is a product
of the Photo Products Department,
E. I. du Pont de Nemours & Co. (Inc.),
Wilmington 98, Delaware.

Printed in U. S. A.



NEW! **CRONAFLEX** Drafting Film offers best surface every time you use it

CRONAFLEX* is the only drafting film made entirely by Du Pont. It is an exclusive combination of a superior surface on Du Pont's unique CRONAR* polyester film base. Du Pont makes the surface and the base in one complete process that assures you of consistent quality. Every piece of CRONAFLEX Drafting Film has been subjected to the most careful supervision during its entire manufacturing cycle. The .004" thickness of this new drafting film makes it easy to handle and to file.

The surface: ideal for pencil . . . erases easily . . . smear-resistant . . . clearer than cloth—you get faster print-through speed with greater uniformity . . . accepts ink.

The base: holds size . . . flexible . . . unexcelled strength . . . moisture-resistant . . . easy to handle . . . lies flat.

CRONAFLEX Drafting Film is available *now* in many put-ups and sizes . . . in either roll or sheet form . . . matted one or two sides. For additional information, and the name of your nearest dealer, *clip* the coupon on the preceding page (you'll never be able to tear it!) and send it in.

E. I. du Pont de Nemours & Co. (Inc.) Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

*Du Pont registered trademarks

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Circle 421 on Page 19

Employees are never "all thumbs" if you use **SCREW STICK** *to increase production profits*

Profit Improvement Program

Look here

at the way SCREWSTICK slips quickly into pneumatic driver . . . ready to feed automatically for one-handed assembly. No fumbling to pick up individual fasteners. No lost time when small fasteners are dropped. No special training of operators needed . . . anyone can do it. Can cut assembly time in half.

Look here

at the way SCREWSTICK assures positive alignment between screw and threaded hole. Provides constant measured torque. Eliminates stripped threads, damaged surfaces, rejects Find out how SCREWSTICK can contribute to your Profit Improvement Program.

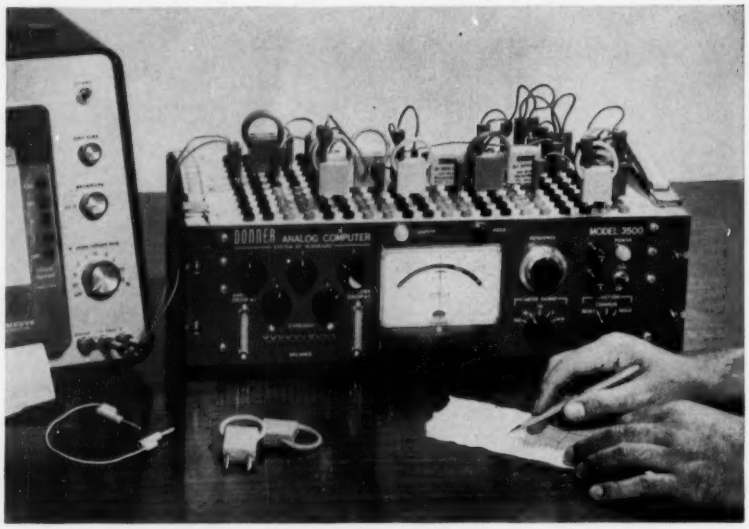
Profit Improvement Program

Buy here

The biggest News in Fasteners come from

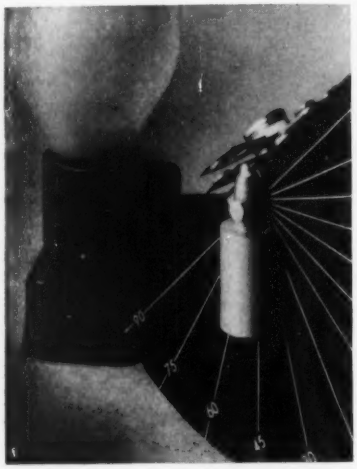
American
SCREW COMPANY
WILLIMANTIC, CONN.
Chicago, Ill.
Detroit, Mich.

Circle 423 on Page 19



Electronic Eggheads Get Smaller

Smallest full-fledged analog computer made on a production basis can be used to study almost any physical system that can be described by linear differential equations. The ten-amplifier unit weighs just 23 lb and is 5¼ in. high, 19 in. wide, and 10¼ in. deep. It will solve a seventh-order differential equation or a ninth-degree Laplace transform. Two or three of the computers slaved together will solve more complex problems. Developed by Donner Scientific Co., Concord, Calif., the device also functions as a versatile piece of laboratory test equipment. It can be converted to a power supply, low-frequency signal generator, voltmeter, or a tester for vacuum tubes, diodes, and transistors.



Tumble Turns Off Current

Fire hazard is minimized when appliances are protected by this new gravity switch. Contact is maintained only when the appliance is in proper operating position. Knock it over and a pendulum breaks contact, shutting off a potential source of fire or injury. Bryant Electric Co., Bridgeport, Conn., says the switch, rated at 15 amp, 118 v, or 8 amp, 236 v, is available with spade or screw type terminals.

New Resin Coating Resists Radiation

NEW YORK—An epoxy resin coating that will withstand high-intensity gamma radiation will "reinforce" concrete and steel in the NASA's Plum Brook reactor now under construction near Sandusky, Ohio.

One of the problems facing designers of this reactor was possible leakage of water, contaminated by accidental release of radioactive material, through concrete retaining walls within the reactor building. A coating was required that would prevent such leakage and which could be decontaminated in the event of exposure to radioactivity. Other epoxy resin formulations have seen service on some low-power atomic installations of the AEC, but no coating has ever been exposed to the radiation intensity of the 60-megawatt power source which will be generated at Plum Brook.

Shell Chemical Corp., New York, and Patterson-Sargent Co., Cleveland, developed a coating which NASA engineers expect to stand up

EC-1357 cuts costs, makes possible stronger sandwich panels

LABORATORY TESTS show EC-1357 provides the high strength and rigidity called for in nonload-bearing sandwich structures.

3M Adhesive EC-1357 bonds all kinds of skin and core materials *without heat.* You'll speed production, cut costs, build in high strength for non-load-bearing sandwich panels.

You can force-dry the solvent out of the adhesive prior to bonding. And a nip roller or cold press is all that is required to complete the bond.

EC-1357 provides maximum immediate strength. And the bond continues to strengthen as it cures at room temperatures.

Dark in color, EC-1357 absorbs infrared heat quickly, dries fast; so no production delay is necessary. And it sprays on with minimum cobwebbing, thus saving materials.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Consult 3M Research. Contact your 3M Field Engineer. Or, for information and free literature, write: A.C.&S. Division, 3M, Dept. YQ-109, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

GEARBELT DRIVES

GEARBELT ADVANTAGES:

- **A POSITIVE DRIVE.** No slip, creep or backlash.
- **STEEL CABLE** strength member will not stretch, needs minimum take-up.
- **FREEDOM** from high initial belt tension. Reduces bearing loads, increases life.
- **COMPACT.** Gearbelts permit smaller pulleys, shorter centers, narrower belts.
- **LIGHTWEIGHT.** High horsepower-to-weight ratio.
- **LESS NOISE.** No vibration, no chatter.
- **LESS HEAT** because virtually no friction.
- **SPLIT TAPER BUSHING** grips pulley on shaft with vise-like pressure. Quick, easy mounting and removal.

Here is a versatile new drive that provides high mechanical efficiency *plus* the inherent flexibility of belts. Browning Gearbelts engage matching pulleys with the positive action of gears, yet without their disadvantages. They eliminate metal-to-metal contact, lubrication, vibration, chatter. Require minimum maintenance.

Browning Gearbelt Drives provide cost-saving advantages in scores of applications, particularly those which require high capacity in limited space, or freedom from stretch and take-up. Ask your Browning distributor for complete information, or write us for Catalog GB-201.

Browning Manufacturing Company
Maysville, Kentucky

Browning POWER TRANSMISSION EQUIPMENT
COUPLINGS • PAPER PULLEYS • BEARING UNITS

indefinitely under the most extreme service conditions—on the concrete and steel located just a few feet from the heart of the reactor. It is a two-part, cold-curing coating requiring a curing agent to complete the chemical reaction which hardens the resin. The same basic epoxy resin is used for the red primer coat, the gray mastic coat into which glass cloth is embedded, and the white finish coat. Coating thickness is 23 mils on the concrete, 16 mils on the steel.

Sperry Award for '59 Won by De Havilland's Comet

NEW YORK—World's first successful jet-powered airliner, the Comet, has won for De Havilland Aircraft Co., Great Britain, the coveted Elmer A. Sperry Award for 1959. The award recognizes a distinguished contribution which, through application proved in actual service, has advanced the art of transportation.

After two Comet crashes in 1954, an intensive program revealed and corrected unsuspected metal fatigue problems. Since then, the airplane has been an unqualified success. Comet IV is now in regular service in many parts of the world.

Meetings and Shows

Nov. 9-11—

Steel Founders' Society of America. 14th Technical and Operating Conference to be held at the Carter Hotel, Cleveland. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Nov. 9-12—

National Electrical Manufacturers Association. Annual Meeting to be held in Atlantic City, N. J. Additional information can be obtained from NEMA, 155 E. 44th St., New York 17, N. Y.

Nov. 11-14—

Society of Naval Architects and

Marine Engineers. 67th Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Further information is available from SNAME headquarters, 74 Trinity Place, New York 6, N. Y.

Nov. 12-13—

American Society of Industrial Designers. "Planning by Design" Conference to be held at the Statler Hotel, New York. Further information is available from society headquarters, 15 E. 48th St., New York 17, N. Y.

Nov. 16-19—

Fifth Conference on Magnetism and Magnetic Materials to be held at the Sheraton-Cadillac Hotel, Detroit. Conference is sponsored by the American Institute of Electrical Engineers in co-operation with the Office of Naval Research; the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers; the American Physical Society; and the Institute of Radio Engineers. Additional information can be obtained from D. M. Grimes, Dept. of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

Nov. 16-20—

American Rocket Society. Annual Meeting to be held at the Sheraton-Park Hotel, Washington, D. C. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Nov. 17-20—

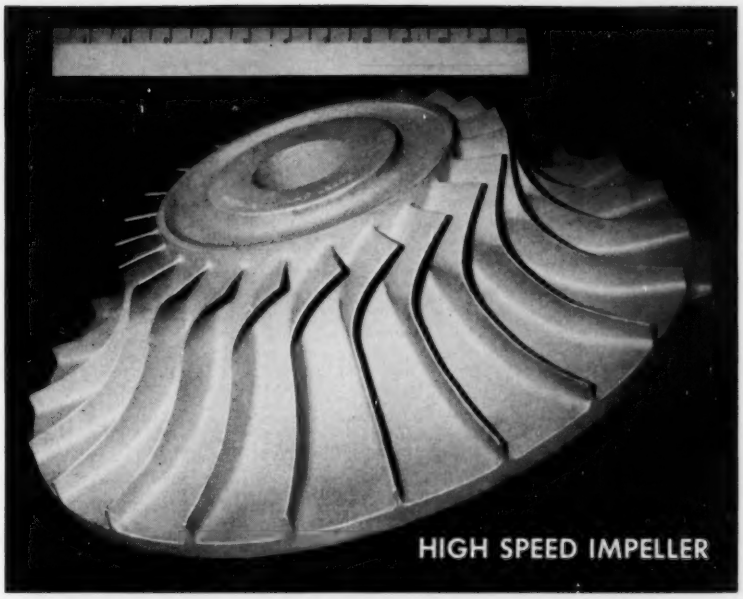
Packaging Machinery Manufacturers Institute Show to be held at the New York Coliseum. Additional information can be obtained from show managers, Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Nov. 23-25—

American Management Association. Conference on "Capitalizing on Technology" to be held at the Ambassador Hotel, Los Angeles. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

Nov. 23-25—

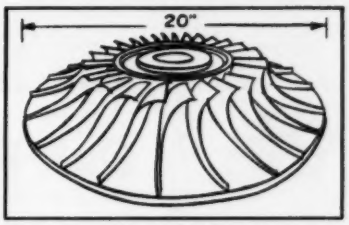
Fluid Controls Institute Inc. Fall



CONVERSION TO STEEL CASTINGS EFFECTED SAVINGS OF OVER 50%!

HERE'S HOW ONE MANUFACTURER SAVED OVER 50% IN PRODUCTION COSTS BY CONVERTING TO LEBANON STEEL FOUNDRY'S CERAMICAST PROCESS . . .

This Third Stage High-Speed Impeller was produced for the Carrier Corporation, Syracuse, New York. The Impeller was originally designed and manufactured as a forging, with the curved blades welded in place. Mechanical properties were good, but production costs extremely high.



Lebanon's Foundry Engineering Service solved the problem by producing the Impeller as a one piece steel casting in a unique combination of the CERAMICAST Process and other precision methods. It is now cast of Circle L 205, Grade A1-ASTM No. A-148-55, Grade 105-85. The use of a Lebanon Steel Casting has effected savings of over 50% while maintaining equal mechanical properties. During tests the Impeller attains a speed of over 12,500 rpm—held for 30 minutes.

Steel component parts now being machined, forged or fabricated can often be CAST BY LEBANON at considerable cost savings, with improved design and physical properties. Lebanon's Foundry Engineering Service will review your requirements and make specific recommendations if a conversion to steel castings can achieve lower costs for you.

DETAILED CASE HISTORIES of this and other cost saving applications, in a wide range of industries, will be sent on request. Write today for your copy.

LEBANON STEEL FOUNDRY

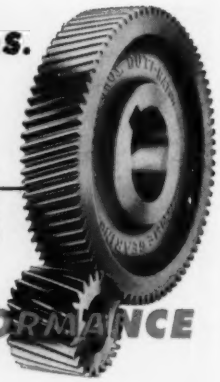
CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS
148 LEHMAN STREET LEBANON, PENNA.

Circle 426 on Page 19

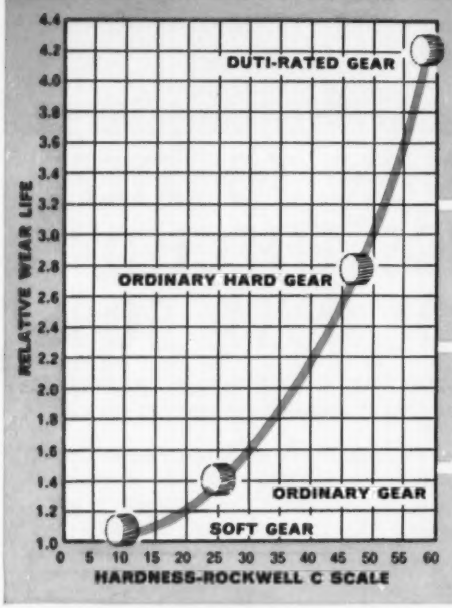
HERE'S WHY FOOTE BROS.

Duti-Rated
LIFETIME GEARING

GIVES BETTER PERFORMANCE
...LONGER LIFE



GEAR PERFORMANCE COMPARISON CHART



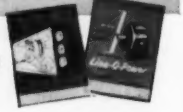
DUTI-RATED GEAR—
Hardened after cutting. Precision processing permits maximum hardness while holding accuracy within extremely close tolerances.

ORDINARY HARD GEAR—
Hardened after hobbing and shaving; hardness limited to maintain reasonable accuracy.

ORDINARY GEAR—
Hardened before cutting; hardening limited to maintain machinability.

SOFT GEAR—
Low hardness—excessive size required because of low capacity.

Write for SHAFT MOUNTED and LINE-O-POWER Catalogs
See how You can get more for Your Drive Dollar!



100 YEARS SERVING INDUSTRY 1859-1959

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS

Meeting to be held at the Drake Hotel, Chicago. Additional information can be obtained from institute headquarters, 320 Broadway, New York 7, N. Y.

Nov. 29-Dec. 4—
American Society of Mechanical Engineers. Annual Meeting to be held at Chalfonte Haddon Hall, Atlantic City, N. J. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Nov. 30-Dec. 3—
Eastern Joint Computer Conference to be held at the Statler Hotel, Boston. Sponsors are IRE and AIEE. Further information can be obtained from Margaret Fox, Secretary-treasurer, EJCC, P. O. Box 4999, Washington 8, D. C.

Dec. 15—
Material Handling Institute Inc. Annual Meeting to be held at the Savoy-Hilton Hotel, New York. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Dec. 17—
Institute of the Aeronautical Sciences. Wright Brothers Lecture to be held at the Natural History Bldg. Auditorium, Smithsonian Institution, Washington, D. C. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

". . . and to my left, we have a chart containing the up-to-the-minute data."

Circle 427 on Page 19

THOMSON TAKES EXTRA PAINS TO PREVENT FASTENING HEADACHES!
Statistical quality control procedures plus 100% inspection give double assurance of close adherence to specified rivet dimensions and positive protection against interrupted production.

YOU GET PRECISION FASTENING AT MASS PRODUCTION COSTS...

. . . when Thomson becomes your fastening partner.

In the Thomson line of more than 8,000 rivet designs, you'll find the semi-tubular, deep-drilled, bifurcated (split), shouldered or compression rivet that will give you the best strength-cost ratio in the fastening field. Produced to the industry's highest quality standards at production rates exceeding 20,000,000 rivets a day, these low-cost fasteners merit serious consideration in your product-improvement and cost-reduction programs.

Our leadership in solving fastening problems with quality rivets and precision rivet-setting machines since 1885 is at your service. What is your problem?

JTL

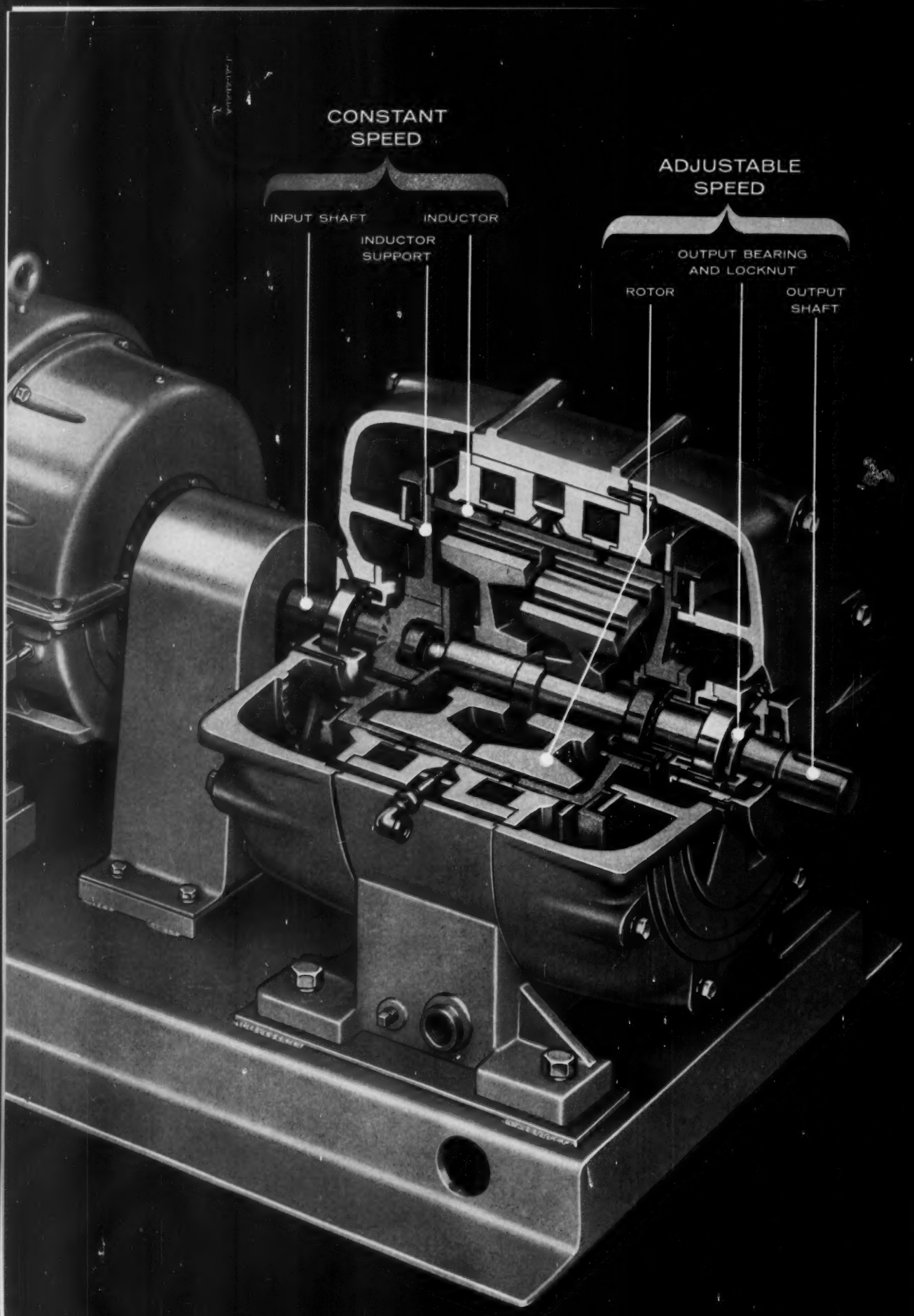
JUDSON L.

THOMSON

MFG. CO., WALTHAM 54, MASS.

Rivets and Rivet-Setting Machines

Offices: NEW YORK • ILLINOIS • INDIANA • OHIO • MICH. • PENN. • CALIF. • FLA. • TEXAS • MISSOURI • S. CAROLINA • ONTARIO, CAN.


CONSTANT SPEED
ADJUSTABLE SPEED
INPUT SHAFT
INDUCTOR
INDUCTOR SUPPORT
OUTPUT BEARING AND LOCKNUT
ROTOR
OUTPUT SHAFT

Another new product from Louis Allis

Just a few of many application possibilities:

Test stands
Adjustable-frequency sets
Paper-machine drives, line shaft, sectional, or helper
Extruder drives
Rubber and paper calenders
Wire-drawing machines
Pumps and blowers
Kiln drives

The new Louis Allis MAGNETIC DRIVE

A compact, precise adjustable speed drive up to 2000 hp!

If you use adjustable speed drives up to 2000 hp, you ought to know about the special features available in the *all-new* Louis Allis Magnetic Drive. Based on a liquid-cooled magnetic coupling design, this outstanding drive offers you the finest in precise regulation, compactness, and design flexibility.

A unique annular cooling manifold distributes the coolant over the outer surface of the inductor drum to provide an effective heat transfer. "Water drag" is eliminated, since there is *no* liquid in the air gap between the constant speed and adjustable speed members.

This new cooling principle eliminates "flooding" the Magnetic Drive and forcing of water into the bearings. And you'll never find condensation in the bearings, because the annular manifold design permits a planned flow of air through the drive at all times. This reduces bearing temperature and carries away any condensation which might occur as the unit cools off after use.

The design also incorporates stationary field construction, thus eliminating slip rings. All bearings can be easily lubricated without disassembly, and grease chambers provide ample grease reservoirs.

Other features include field coils and lead connections encapsulated in a special chemical and heat-resistant polyester — simplified construction for easy inspection and servicing — and versatile design for simple relocation of cooling inlet, conduit box, discharge, etc., regardless of direction of rotation.

If your plans call for adjustable speed drives — specify Louis Allis Adjustable Speed Magnetic Drive. For a complete description of these new drives, write for Bulletin 3650 — now available at your Louis Allis District Office or from The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

Two-field construction shown. Also built in one, three, or four-field construction with or without magnetic brakes. Simply specify your hp and speed requirements and Louis Allis will tailor the drive to your need.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

Circle 428 on Page 19

LOUIS ALLIS

A55-132

ORCO

"Customeered" components basic to industry

ideas on "Customeered"

RUBBER PARTS

...their design and application for improved product performance No. 2

8-ft. rubber-metal "sandwich" resists chewing by weather, oil and millions of vehicles

Bonded-rubber component assures higher accuracy, longer operating life of vehicle detector contact unit

Pressure-sensitive detectors installed flush with roadway surfaces are vital factors in today's ever expanding vehicular world—are used for traffic control, toll collection, automatic door opening, etc.

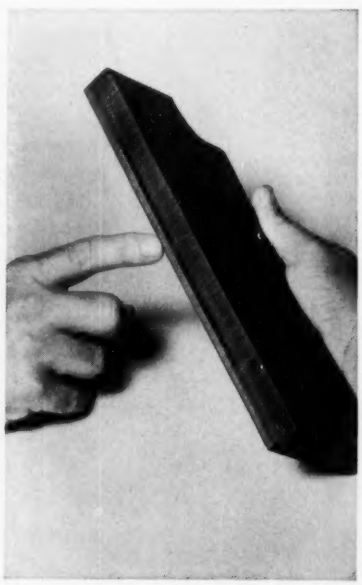
A contact unit produced from molded-rubber bonded to heavy-gauge and thin-gauge metal strips serves as an actuator in the detectors. The pressure of a vehicle passing over the contact unit mounted on a steel frame below the surface of the road puts the detector to work—initiates a count or any specific action the detector is designed to perform.

The requirements for the sandwich-like bonded-rubber component comprising the contact unit: A completely waterproof and airtight air space within the full length of the one-foot wide units produced in varying lengths of four, six, eight and ten feet; resistance to the harmful effects of constant exposure to weather, sunlight, salt, oil and tire chains; an operating life involving a minimum of many millions of crossings by all types of vehicles.

The resulting design involved an exceptionally difficult molding and bonding job. Included were combinations of hard and soft rubbers. Careful attention had to be paid to many important and minute details of production and intricate design not only to meet the customer's stringent requirements for longer operating life but also to make good on rigid PSI specifications.

Ohio Rubber's wide and varied experience in "customeering"* to unusual specifications, as well as its broad, up-to-the-minute manufacturing facilities, were both equal to the challenge—successfully met all the requirements. The bonded, molded-rubber contact units are in regular production at Ohio Rubber.

PHOTO COURTESY AUTOMATIC SIGNAL DIVISION, EASTERN INDUSTRIES, INC.



MOLDED-RUBBER TUBE STORES AND PUMPS CLEANING FLUIDS

A most important part in the new Swirl-away Cleaner for walls, upholstery, woodwork, etc. is a molded-rubber tube which serves both as a secondary storage tank and vacuum pump for cleaning fluid. Unusual in shape and requirements the tube involved a complicated mold, close tolerances, and a control rate stock with particularly high resistance to harsh chemicals normally found in detergents. Problems on the design and production of this intricate rubber component were successfully worked out by engineers at Ohio Rubber where the part is now produced.

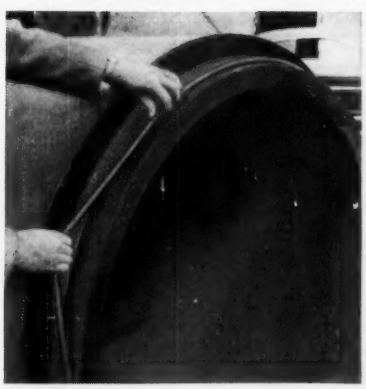
RUBBER-METAL PUMP IS KEY TO NEW DISHWASHER FEATURE

A vital component in a dual action pump which makes possible a "flush-away drain" feature in the dishwashers of a leading manufacturer, is a rubber-metal housing. Since rubber was required at several points for sealing and vibration absorption, the manufacturer asked Ohio Rubber engineers for help in designing and producing a pump housing of molded rubber bonded to a carbon-steel frame or insert. The material in the housing, which is in regular production at Ohio Rubber, also fully protects the frame from corrosive effects of both water and detergents.

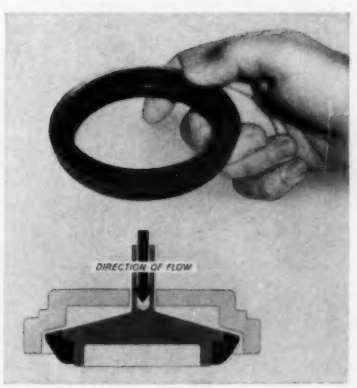
THERE ARE MANY MORE EXAMPLES

of how Ohio Rubber "Customeered"* components are helping to improve product performance for outstanding original equipment manufacturers in every industry. For more information on Ohio Rubber "Customeering"*—molding, extruding, bonding-to-metal—with rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl, write today to The Ohio Rubber Company, Willoughby, Ohio. 9DE2

**Trademarks of The Ohio Rubber Company*



Sewer-Pipe Seal – Precision extrusion of high specification rubber by ORCO provides an effective new approach for obtaining sealed or "premium joints" in sewage disposal lines—prevents surface water infiltration to reduce treatment costs. Available in a wide range of popular sizes, plus close tolerances, for concrete as well as clay pipe.



Orthane Valve Seat – Durable as the hardest steel yet resilient enough for sealing, this valve seat of molded polyurethane by ORCO is used in specialized oil field operations where it must successfully withstand the highly abrasive impact of raw crude oil mixed with gravel at pressures which often go as high as 20,000 PSI.

THE OHIO RUBBER COMPANY

Willoughby, Ohio

ORCO

A DIVISION OF THE EAGLE PICHER COMPANY

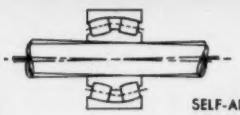
Circle 432 on Page 19

Now! *Hoover Quality*

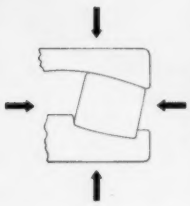
HOOVER *super finish* RACEWAYS AND ROLLERS

SPHERICAL Roller Bearings

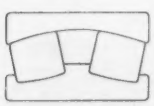
Complete Range of Series and Sizes



SELF-ALIGNING—Hoover spherical roller bearings automatically compensate for shaft misalignment in any direction, either initially or dynamically under load.



RADIAL OR THRUST LOADS—Double row of large-size rollers provides capacity for heavy radial and shock loads. High contact angle provides substantial thrust loads in either direction.



ACCURATE ROLLER GUIDANCE is assured by heavy center flange guide, asymmetrical roller design and heavy machined bronze, land-riding retainers.

Hoover Quality spherical roller bearings have two rows of large-size convex rollers to provide exceptional radial and shock load capacity. In addition to the important features illustrated above, Hoover spherical roller bearings utilize a land-riding, machined solid bronze retainer capable of withstanding high stress. Hoover roller guidance features, plus precision matching of *Super Finish* rollers and raceways, assure uniform load distribution, low operating temperatures and enduring performance. Available in a complete range of series and sizes—with cylindrical or tapered bore.

HOOVER BALL AND BEARING COMPANY MD-10
5400 South State Road, Ann Arbor, Michigan

Please send information about the roller bearings checked:

☐ Have your representative call.

☐ Spherical roller bearings ...Bulletin No. 113

☐ Cylindrical roller bearings ...Bulletin No. 114

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

In Roller Bearings

ASSURE EXTRA LONG LIFE . . . SUPERIOR PERFORMANCE

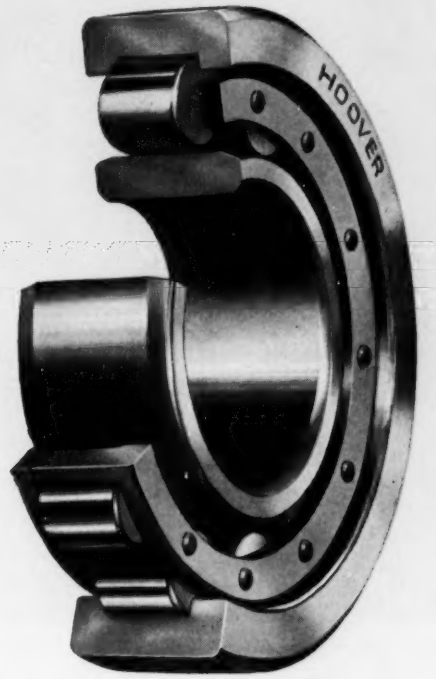
Depend on Hoover to set new high standards for roller bearing quality . . . *Hoover Quality!*

In roller bearings, *Hoover Quality* means that raceways and rollers are *Super Finished* to gleaming, mirror-like smoothness. It is this *Super Finish* that results in longer bearing life and superior performance.

Hoover enters the roller bearing field with complete lines of the most widely used of spherical and cylindrical types. Hoover roller bearings are accurately made of the finest of materials. They utilize the most successful of operating and design features. They assure you the best in roller bearing performance for a wide range of applications.

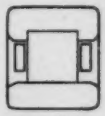
CYLINDRICAL Roller Bearings

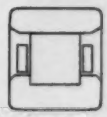
Complete Range of Series and Sizes

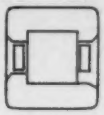


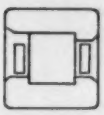
Hoover Quality cylindrical roller bearings are designed with crowned rollers that provide uniform load distribution for maximum radial load capacity and minimum friction. Because they are cool running, high speed operation under heavy radial loads is possible.

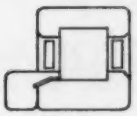
Rollers and raceways are *Super Finished* to mirror-like smoothness for quiet operation and long life. Retainers are machined solid bronze assuring strength and accurate roller guidance. Available in a complete range of series and sizes in the types pictured at right.


Type NU—Straight inner race


Type N—Straight outer race


Type NJ—Single flanged inner race


Type NF—Single flanged outer race


Type NH—Single flanged inner race with stabilizing ring

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Zone Sales Offices and Warehouses

8581 South Chicago, Chicago 17, Illinois
290 Lodi Street, Hackensack, New Jersey
2020 South Figueroa, Los Angeles 7, California

Circle 433 on Page 19

80-ton trailer hauls 5 times its own weight!

LeTourneau-Westinghouse designed this bottom-dump hauling unit to carry the greatest payload with the least possible empty weight. The trailer weighs only 15½ tons but will haul a whopping load of 80 tons or more. This gives it an extremely high ratio of payload to weight and makes the unit most economical on fuel, tires and other operating costs. The trailer differs radically in design from conventional units. Much of the body is built from USS MAN-TEN Brand High Strength Steel to save weight. Sides are corrugated ⅛-inch MAN-TEN having the equivalent bridge strength of ¾-inch carbon steel. Wear plates on the front and back slopes are 3/16-inch MAN-TEN to assure high resistance to abrasion and impact. The highly stressed rear-axle assembly was built with USS

Mr. Big hauls as much coal as 1¼ railroad cars but weighs less than most 50-ton capacity trucks. USS Special Steels make the difference.

. . . built from USS MAN-TEN and USS "T-1" Steels

"T-1" Constructional Alloy Steel which has an extra high yield strength of 100,000 psi.

This combination produced a tough wear-resisting unit that would take the beatings from coal or rock. Both steels saved weight and resulted in a payload increase of 10 tons over conventional construction. In 21,000 miles of operation, no sign of structural weakness or body fault has been observed.

Design equipment with USS Special Steels . . . MAN-TEN for strength with economy, COR-TEN for strength with superior corrosion resistance, TRI-TEN for strength with toughness and "T-1" for extra high strength and impact abrasion resistance. For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS, MAN-TEN, COR-TEN, TRI-TEN and "T-1" are registered trademarks

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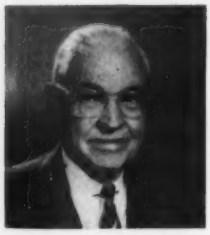
RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

The choice between a cap screw and socket head screw

If you have the choice, make it a socket screw when you have a space problem, but choose the cap screw for more holding power per dollar.

No question that you should apply socket screws in counterbored holes; and that you can clear tight spaces. What you can't do is utilize the full strength of the alloy needed for the socket head. And remember, strength of a connection depends on how you preload the fasteners, and not on the strength of the fastener material alone.

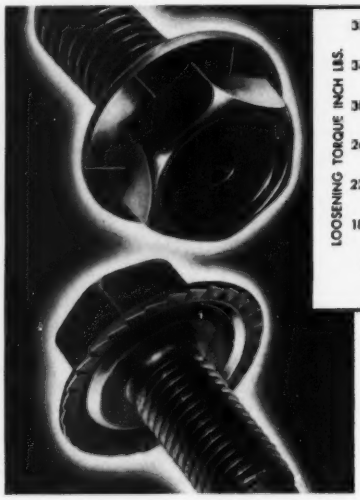
THE HANDICAPS OF ONE

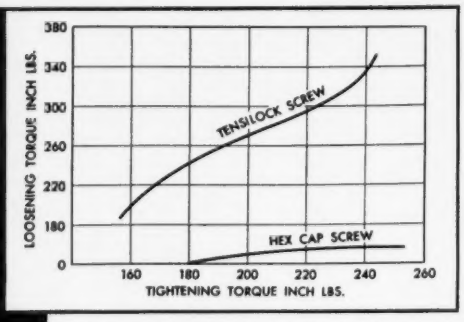
Internal wrenching rarely develops as much torque as needed for proper preloading. And if high torque is developed, the smaller bearing area of the socket head tends to crush the surface on which it bears rather than increase tension or preload.

THE ADVANTAGES OF THE OTHER

If you design to take advantage of heat treated cap screws of SAE grade 5 quality, you'll get a stronger connection at lower cost. These standard fasteners have ample bearing and wrenching surfaces, can be torqued right up to yield strength. They also cost less than the alloy fasteners.

New TENSILOCK* Screws seat tighter, lock tighter





Graph shows example of on-torque and off-torque relationship. It takes more torque to loosen than to tighten.

RB&W's new TENSILOCK screws, the toothed fasteners with high tensile locking, are identified by six radial dashes on flange.

Head has integral washer face with teeth that lock fastener to surface. Circular groove allows flange to flex and seat to bear solidly on surface.

RB&W's TENSILOCK fasteners feature ratchet-like teeth formed at an angle which cuts driving effort yet which enables the teeth to bite in firmly and give an improved grip against back-off.

In addition, a circular groove in the integral "washer" permits the flange to flex upon tightening, and helps maintain tension in the fastener and pressure on the teeth.

IMPROVED TENSION TO TORQUE RATIO

With reduced friction under the head, the new tooth design has enabled more of the wrenching torque to be used to develop tension and less to overcome friction. Since the flange flexes, it allows the screw to bear solidly on its seat. All of the high strength capabilities of these heat-treated one-piece fasteners can now be attained for a stronger assembly.

MORE LOCKING POWER

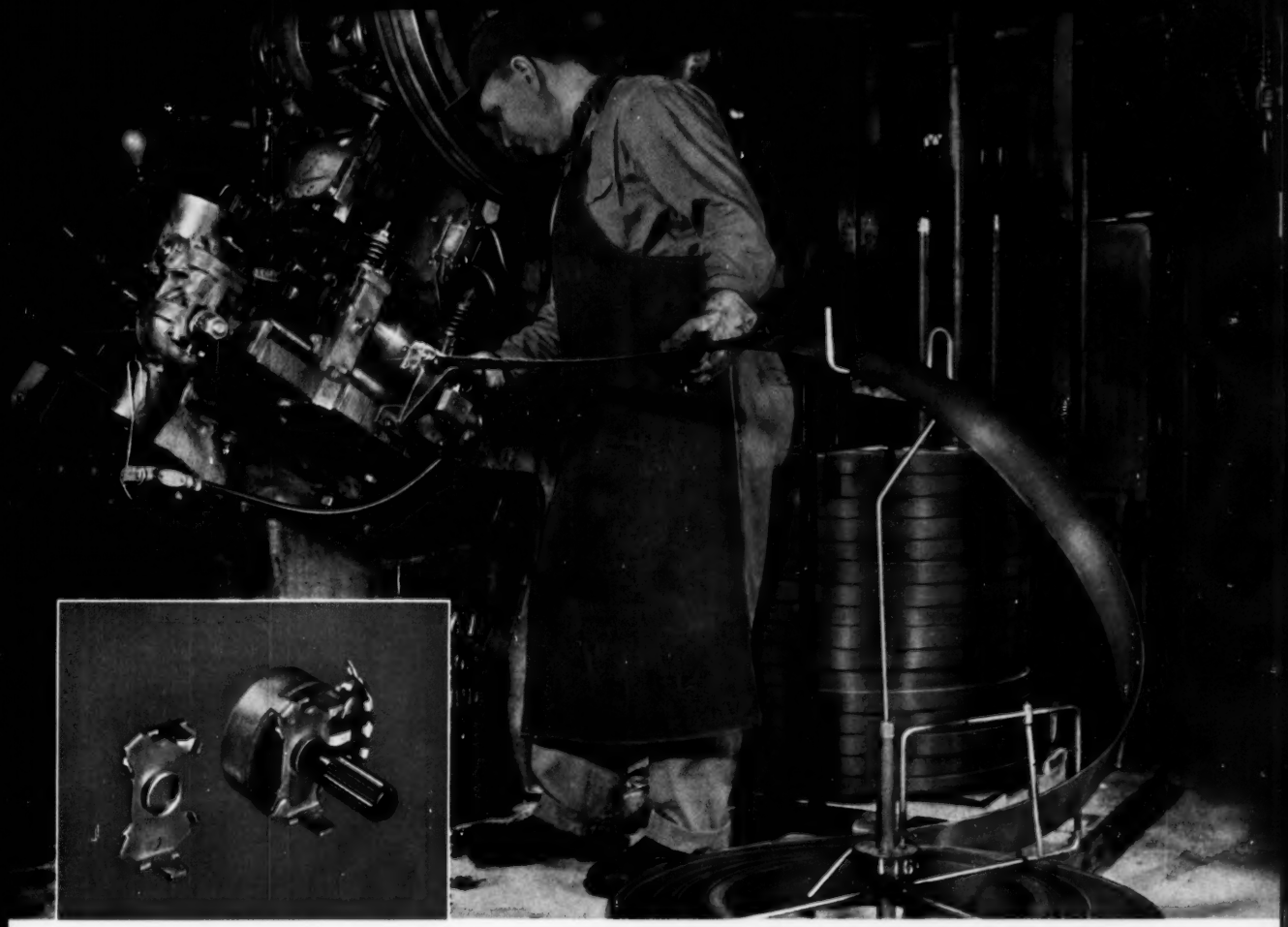
Tensilock screws need up to 40% more off-torque than on-torque. Combining this feature with the higher residual tension, and the diaphragm action of the integral washer face, these fasteners give superior locking and holding power for permanently tight, strong joints . . . even under severe vibration and cyclic temperature changes.

Now available in limited range of screw types (not in flat head), and in various nut sizes. For details, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York. ** Trade Mark Pat. applied for.*

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 434 on Page 19

Circle 435 on Page 19→



COPPER-COATED Thomas Strip coils, 1½" wide, are made into the intricate television control part shown in the inset.

Thomas Strip Is Cost-saver at TV Parts Plant

For 20 years, copper-coated Thomas Strip steel was known at Chicago Telephone Supply Corp.'s Elkhart, Ind., plant as the metal to conquer a metal-working plague—scalloping during deep draws.

Now the precision-rolled product of Pittsburgh Steel Co.'s Thomas Strip Division has new claims to fame. It makes possible a one-piece, extruded and stamped mounting plate used to assemble and connect the variable resistor to the television set chassis.

Previously, Chicago Telephone made the grounding plate and mounting bushing in two pieces. The bushing being a relatively expensive brass mounting device, Thomas' copper-coated makes it possible to blank out the intricate part, punch a hole in its center and then extrude the edge of the hole into a load-bearing neck. All this is done at high production speeds with progressive blank and form dies.

In many applications at Chicago Telephone, similar severe demands are imposed. Examples:

- **THICKNESS TOLERANCE**—As tight as ±.0005". A variation of ±.001" can cause a potentiometer cover to be off .005".
- **UNIFORM TEMPER**—Some parts are made at speeds up to 400 units per minute. Any wide hardness deviation results in troublesome forming variations.
- **SHEARABILITY**—Punched and blanked parts have tolerances so snug that the slightest burr prevents proper assembly.
- **UNIFORM COPPER COATING**—Copper acts as a necessary die lubricant and a base for nickel plating. When the mounting plate was made from plain steel, die life ranged from 40,000 to 62,000 units. Now, with the more difficult mounting plate, die life averages 250,000 units between regrindings.

Whether you need dimensional accuracy, surface, temper, aid to die life, chemistry or design and production advantages, you'll find them in Thomas Strip. It is a controlled rolled steel, plain or in a variety of electrolytic coatings of copper, brass, nickel, zinc, tin, chrome and lacquer with a full range of tempers, widths and finishes. Thomas Strip also is available with an attractive but durable pattern rolled right into its surface. For details, contact any sales office. Do it today.

Thomas Strip® Division

Pittsburgh Steel Company

Grant Building · Pittsburgh 30, Pennsylvania

District Sales Offices:

Atlanta	Detroit	Philadelphia
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Dayton	New York	Warren, Ohio

SEALOL MECHANICAL SEALS

Conditions: 7,000 RPM 250°F. 0-250 PSI cycling pressures

Results: *NO SIGNS OF WEAR – ZERO LEAKAGE*

Picture a ¾" jet engine pump shaft running bone dry at 7,000 RPM, temperatures to 250°F. . . . hour after hour. Suddenly, water surges into the pump, slams into the shaft seal with momentary pressures running to 650 PSI. For 2 minutes, water is pumped at 250 PSI, then back to 4 hours of dry running.

After one thousand hours of continuous service, the seals showed no signs of wear . . . zero leakage during the water cycle. The secret behind this outstanding performance record is in the special "one-thirteen" treatment given the carbon faces.

SEALOL — *the versatile seal*

CURRENT APPLICATIONS

RPM	Shaft Size	Temperature	Fluid	Pressure
51,000	13⁄16"	400°F	Peroxide steam and nitrogen	0-10PSI
17,000	3"	225°F	Air Oil Mist	2-3PSI
37,500	1"	650°F	Mil-O-5606	20-30PSI
13,800	1 11⁄16"	—300°F	LOX	50PSI
3,500	1⅜"	270°F	Acetone, H2S04 and Phenol	80PSI
1,750	1⅞"	100°F	Mercury with 5% water	160PSI
173	1"	210°F	Tomato products	30PSI
25	1¼"	Ambient	Heavy Water	150PSI

YOUR PARTICULAR SEALING PROBLEMS . . . may or may not call for "one thirteen" treated seals . . . or welded metal bellows seals . . . or heavy duty Flexibox-type seals . . . or low cost RS seals.

The important point is that you can look for longer life, lower costs and better performance when you contact your nearest Sealol Engineer for detailed information and recommendations.

Write for further information or . . .

SEALOL CORP.

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CALL your nearest Sealol engineer now.

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Dayton — Axminster 8-3009
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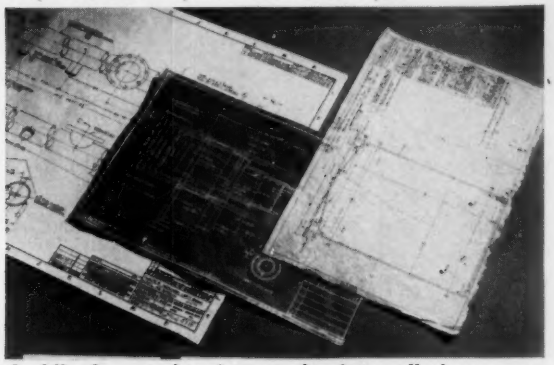
PUT RECORDAK PRECISION MICROFILMING TO WORK FOR YOU . . .

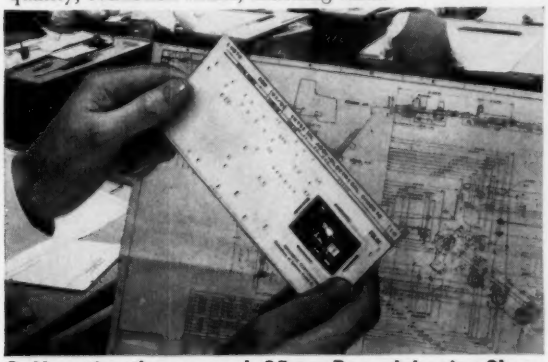
Save time everytime you refer to drawings, everytime you make prints

It's easy to take the *wait* out of drafting—do away with waiting for drawings, prints, revision notices.

Recordak Precision Microfilming automates your bulky engineering drawing files—transforms them into trim decks of cards which can be filed at the fingertips and referred to or copied immediately. Here's how this *unique* Recordak System can work for you:



1. All of your drawings and prints—all sizes, ages, colors—are reproduced with needle-sharp line detail and remarkably uniform backgrounds on low-cost 35mm Recordak microfilm. New Recordak microfilming techniques and quality control methods are responsible for outstanding results which more than meet the most rigid government specifications for resolution quality, reduction ratios, indexing data.



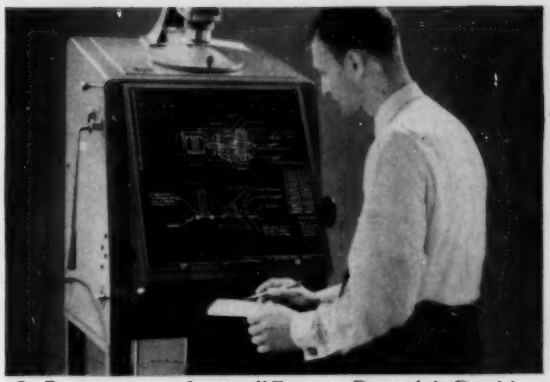
2. Mounting these superb 35mm Recordak microfilms in plain or punched Filmsort aperture cards gives you *an active drawing file* that can be kept right at hand in 5% of space needed for original drawings and prints. Duplicate cards can be made directly from original cards for draftsmen, branches, subcontractors, government agencies! Fifty cards mailed first class for just 20¢!

RECORDAK®

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming

—now in its 32nd year



3. Easy to see what a difference Recordak Precision Microfilming makes. Smallest detail is sharp and clear when cards are projected in Recordak Film Reader. Use of these cards in drafting room cuts need for reference blueprints at least 75%.

4. Another saving in printmaking costs. Whenever paper copies are needed, reduced-size prints can be made directly from your Recordak microfilm cards, or duplicate cards, by photographic, xerographic or electrostatic methods. Here again, Recordak Precision Microfilming pays off in improved print quality.

Free booklet—"must reading" for every engineer and draftsman—gives further details on this new system, available through Recordak.

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Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever.

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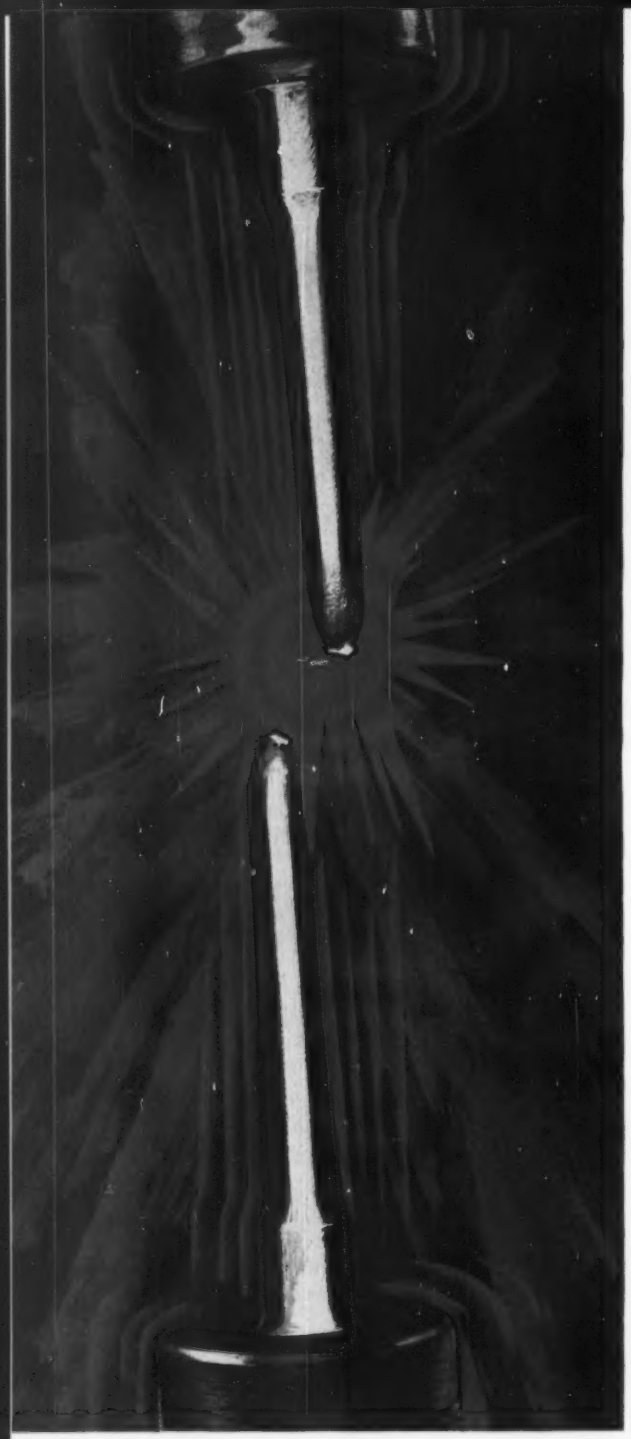


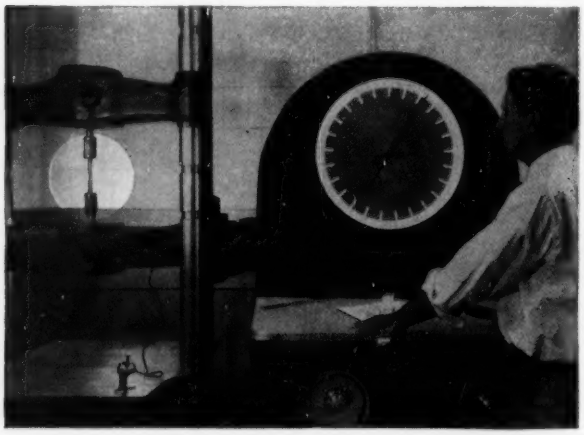
"How Jessop Stretches Specialty Steels"

Robert Timko, Metallurgist

"At Jessop, tensile testing of specialty steels is carried out with far more than ordinary precision. It pays. It's one of the reasons our repeat business is so high.

"Based on a series of photographs, this drawing shows a specimen of type 304 annealed stainless steel bar at the climax of a tensile strength test. Moving apart, the heads of the tensile testing machine stretched the bar until it finally ruptured at 5500 psi above the spec."

In this Jessop metallurgical laboratory, top metallurgists using all types of modern testing equipment help us make certain you get *consistent* high quality in specialty steels. *Specify Jessop . . . and then relax.* VMA 6788



Tensile testing machine in the Jessop metallurgical lab. Stretch, strain and then bang! The specimen of type 304 annealed stainless bar ruptured at 5500 psi above the spec. Tensile strength okay!

In the Jessop metallurgical lab, this tensile testing machine is one of many types of tools used to make certain you get *exactly* what you want in specialty steels.

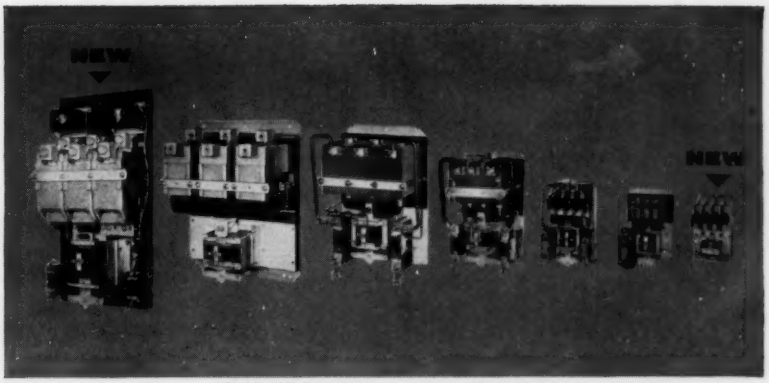
Jessop Steel International Corporation
Steel Warehousing Corporation, Chicago
Green River Steel Corporation
Jessop Steel of Canada, Ltd.

JESSOP
STEEL COMPANY
Washington, Pennsylvania

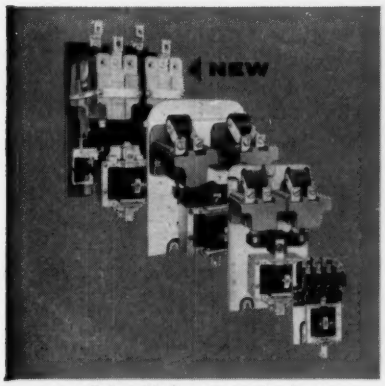
Stainless, alloy, cast-to-shape, clad and forging steels, ground flat stock and other specialty steels

Circle 438 on Page 19

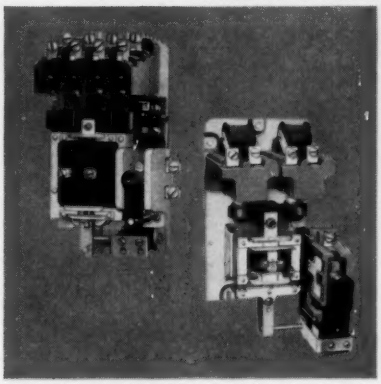
HERE'S A CONTROL COMPONENT LINE YOU CAN STAKE YOUR REPUTATION ON



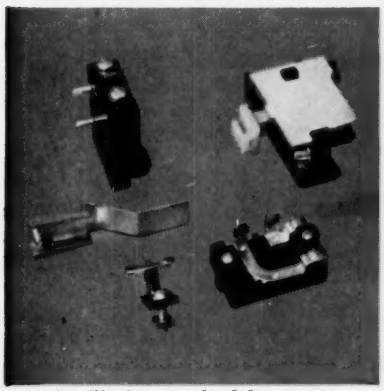
AC Solenoid Contactors • NEMA sizes: 00 to 5



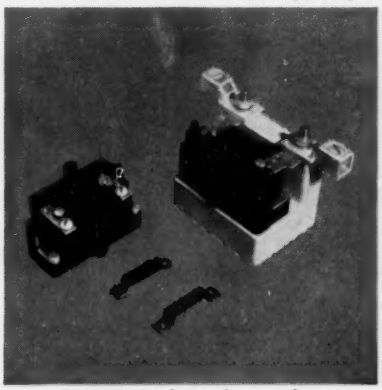
DC Solenoid Contactors to size 4



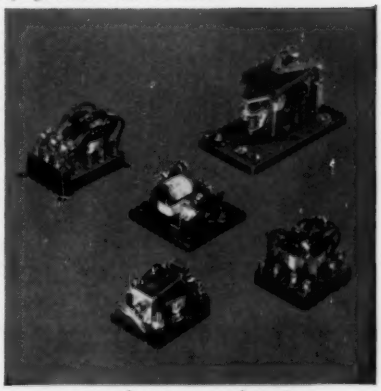
AC and DC units with DC and AC power plants, dynamic brake contacts



Auxiliaries: standard, low power



Dependable thermal O.L. relays



AC and DC power relays, too

It's completely versatile and designed for both standard and specialized controls

From the little Size 00's to the powerful Size 5 contactors you'll find maximum reliability built right in . . . whether your application is in motor control, resistive heating or lamp switching.

Meticulous attention to design features guarantees you top-notch performance . . . especially where hi-reliability is a "must." All AC and DC contactors for example, come equipped with simple, fast-acting, trouble-free solenoids. There are no complicated linkages or potentially troublesome pins or bearings . . . no adjustments needed either.

The main *and* auxiliary contacts are of the double break type designed for maximum reliability even where high inrush currents are met. Contacts are accessible for inspection, too!

Other key contactor design features include: identical mounting centers for AC *and* DC; all units designed for front-of-board wiring *and* mounting; magnetic blowouts furnished above 25 amp. size on DC; fully accessible terminals make installation easy.

On your next control job, standard or special, specify W/L Control Components. Send for detailed Control Catalog: Ward Leonard Electric Co., 58 South St., Mount Vernon, N. Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) 0.8

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Result-Engineered Controls Since 1892

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Circle 439 on Page 19

NEW HIGHER PERFORMANCE FOR FORMCHROME* SPRAGS

On over-running clutch applications, Formsprag clutches have always provided greatest torque capacity for size and weight, no measurable backlash, extreme precision and long trouble-free life. Now! With newly designed Formchrome sprags, the best over-running clutches provide users with even higher performance.

Here's why! The new Formchrome sprags are made of hardened high carbon alloy steel with chromium diffused into the surface to form a chromium-carbide alloy. Thus, the sprag is corrosion resistant, and has high hardness and abrasion resistance similar to tungsten carbides. Result—sprag geometry is retained over a longer period and clutches can be used on higher over-running speeds. The Formchrome sprag is exclusive with Formsprag—no other clutch manufacturer can offer you its performance advantages.

Typical of the higher performance users can now receive from Formsprag clutches is this specific example: A Formsprag clutch using Formchrome sprags was installed in the reaction member of a torque converter and a competitive clutch in another. The competitive clutch showed excessive wear after the equivalent of one year of operation. The Formsprag clutch was run 50% longer and still showed only negligible wear.

There is a Formsprag clutch for every application—from business machines to aircraft. Standard clutches cover a wide range of uses and are described in the Formsprag Catalog . . . send for your free copy. However, to meet unusual requirements, Formsprag engineers will modify a standard clutch or design a special—send your application details.

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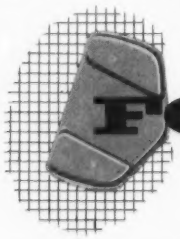
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities

*Formchrome sprags are produced under a patented process. The use of this process in the manufacture of over-running clutches is exclusive with Formsprag.



FORMSPRAG CLUTCHES

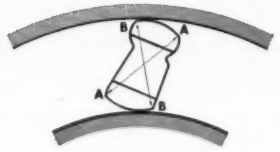
World's Largest Exclusive Manufacturer of Over-running Clutches

TYPICAL APPLICATIONS WHERE FORMCHROME SPRAGS HAVE PROVEN SUPERIOR PERFORMANCE

1. Used in operating submarine missile (Regulus II), Formsprag clutch allows alternator to over-run the hydraulic driving mechanism.
2. Backstop clutch on belt conveyor handling bauxite ore is subjected to higher over-running speed, extreme abrasive dust and hot weather—has been in operation a year.
3. Starter clutch for aircraft ground support system allows high-speed gas turbine to over-run starter unit.

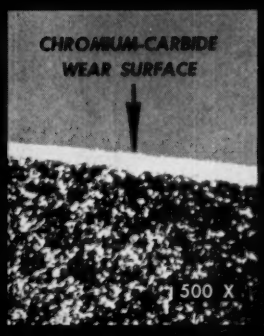
For additional information on how Formchrome sprags assure better performing clutches, write for technical paper "Formchrome Sprags".

HERE'S

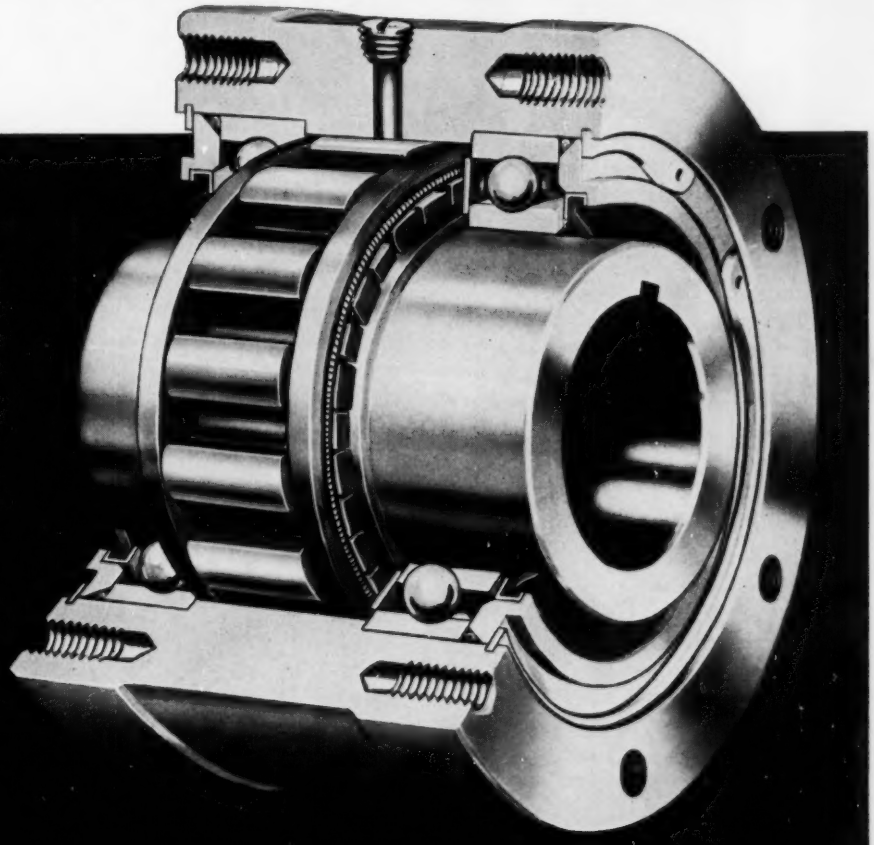


The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

FORMSPRAG OVER-RUNNING CLUTCHES WITH

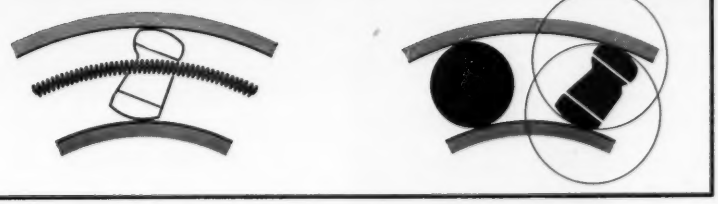


Micro-photo showing chromium-carbide wear surface (1900 Vickers—80 R_c) of Formchrome sprags. Chromium is diffused into high-carbon alloy steel sprag (62R_c).



OVER-RUNNING · INDEXING BACKSTOPPING

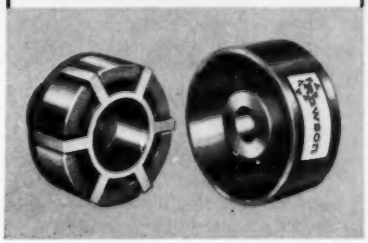
HOW IT WORKS



An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO-LOAD STARTS



Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

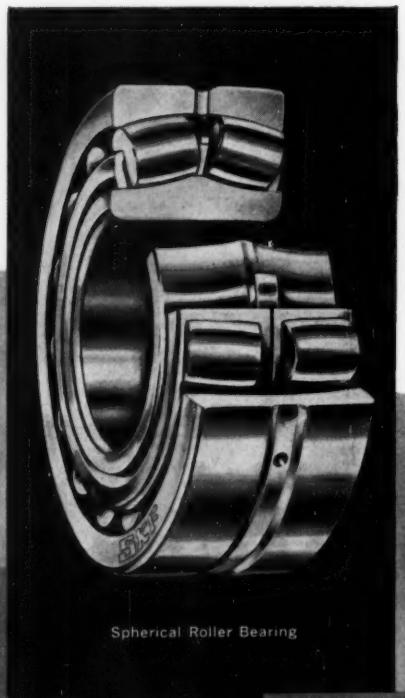
Which of these SKF bearings fits the needs of your design?

SKF continually produces all of these standard bearings—in countless sizes and variations—in production quantities. And practically all of them have exclusive features that benefit you.

Take the spherical roller bearing, for example. Recently re-designed, it now offers 25 to 50% increased capacity and 2 to 3½ times longer service life. Yet it's a standard SKF bearing—promptly available in over 130 standard sizes ranging from 2.4" to 53.5" O.D., with every possible combination of seals, shields and adaptors to meet your specifications.

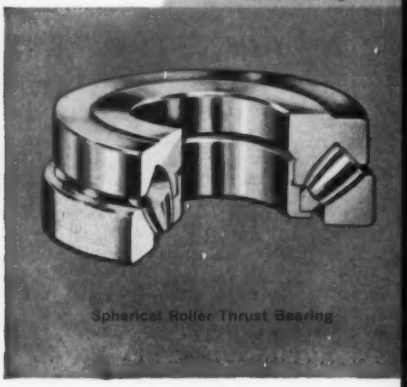
But why not get full details on this—or any other— SKF bearing? Each is made to do an efficient, economical job for you. Call any one of the 25 SKF sales offices today. 5906

Cylindrical Roller Bearing

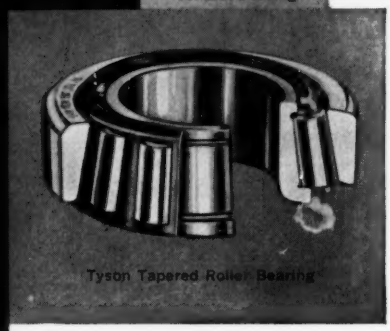


Spherical Roller Bearing

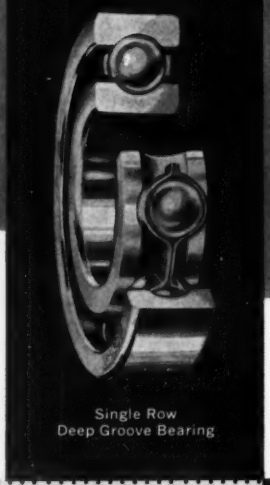
Angular Contact Bearing



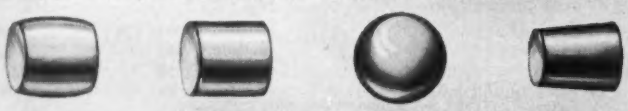
Spherical Roller Thrust Bearing



Tyson Tapered Roller Bearing



Single Row Deep Groove Bearing



Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

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He's located near you, offers more frequent contact. In many cases he stocks standard Formica sheets and rods for Streamliner delivery in a matter of hours.

The new Formica field fabricating service is without equal. It can save you time and money in more efficient parts procurement. Write us for complete information and the name of the fabricator nearest you. Formica Corporation, subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.

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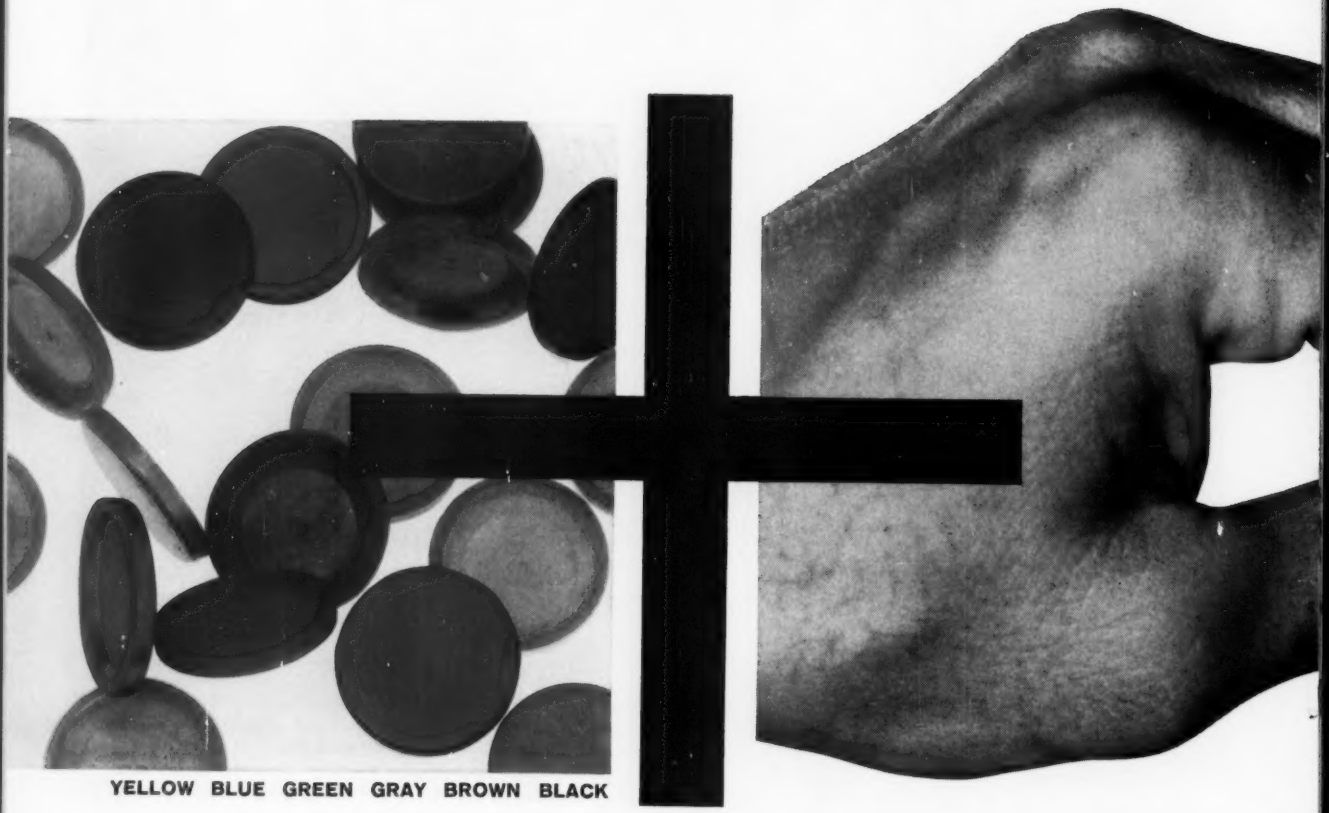
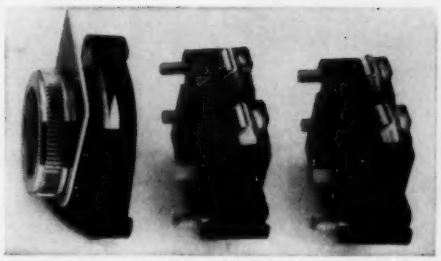
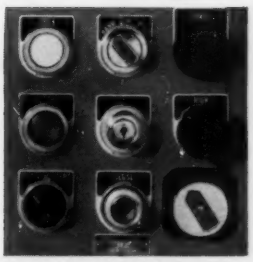


YELLOW BLUE GREEN GRAY BROWN BLACK

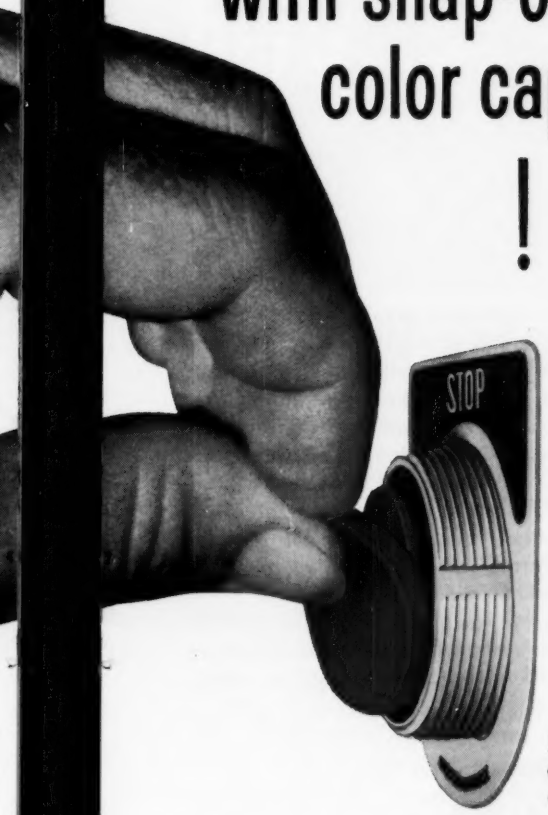
WESTINGHOUSE FLUSH PUSHBUTTON puts the finger on color coding with snap-on color caps !



Shallow contact blocks stack for multiple control circuits. Angled terminals are easy to get at with a screwdriver, even when blocks are stacked.



Available in a full range of operator designs.



HERE'S PRACTICAL PUSHBUTTON COLOR CODING—the economical Westinghouse way. Snap-on color caps let you change colors *without changing buttons.* Simply remove the clamp ring and color caps snap off easily and can be replaced in a matter of seconds.

Simplified color coding is but one of the many pluses for new Westinghouse flush pushbuttons. Thin operator and shallow contact blocks make this pushbutton *thinnest overall.* Contact blocks stack for control of multiple operations, another space-saving feature.

Flush pushbuttons are oiltite, of course. And they meet exacting machine tool and control panel requirements. Available in a full range of operator designs.

Regardless of your pushbutton requirements, order with confidence from industry's most extensive line. Contact your nearby Westinghouse sales office or distributor, or write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa.

J-30304

YOU CAN BE SURE...IF IT'S **Westinghouse**

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Circle 443 on Page 19

ESCO CENTRIFUGAL CASTINGS KEEP

MACH 17 IN A TUBE!

Tremendous pressures and temperatures are generated in this shock tube at Lockheed Aircraft Corp., to simulate conditions encountered by a long-range ballistic missile re-entering the earth's atmosphere. High pressure gas triggers shock waves which travel 17 times the speed of sound. Instantaneous temperatures range above 15,000 degrees F.

The 44-foot long tube is an assembly of *ESCO* heavy-wall Spuncast® castings hydrostatically tested at 10,000 PSI. It is typical of the many exacting casting jobs that wind up at *ESCO*.

Simplify your design problems by calling *ESCO* for special alloy steel Spuncast pipe, standard heavy wall fittings, and special design fittings and valves.

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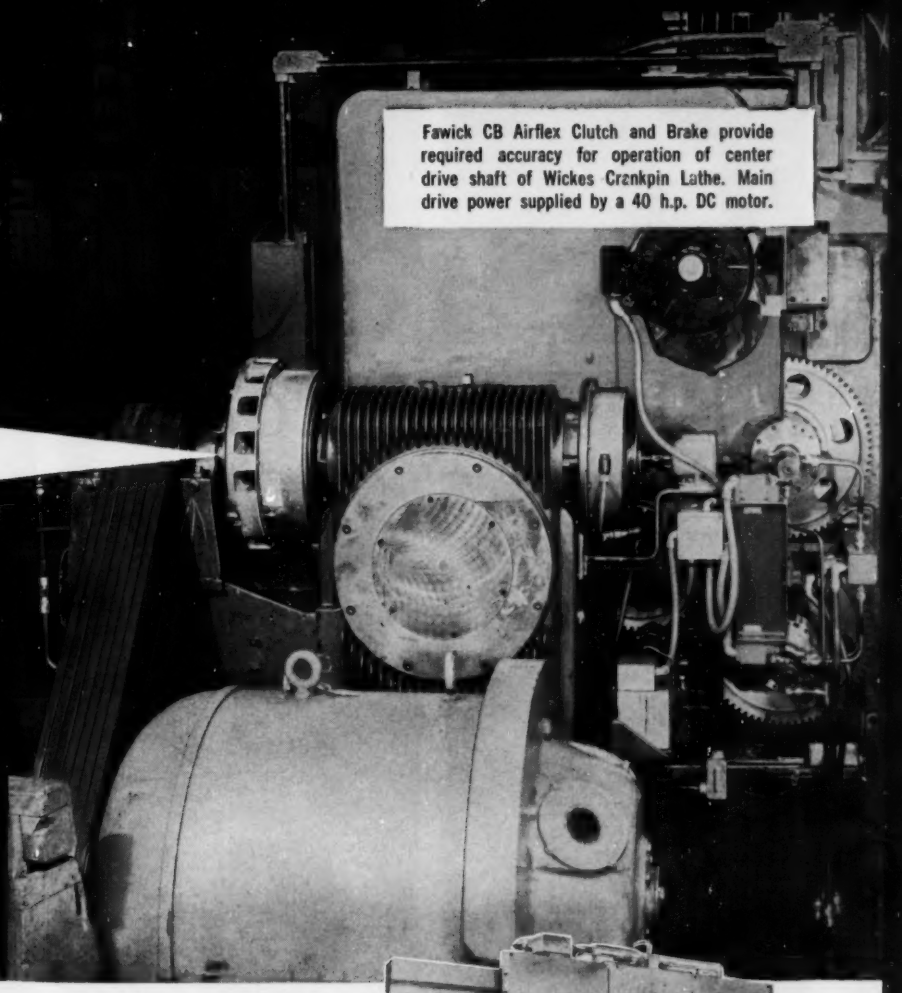
Circle 444 on Page 19

Fawick Clutches here...



Fawick CB Airflex Clutch and Brake provide required accuracy for operation of center drive shaft of Wickes Crankpin Lathe. Main drive power supplied by a 40 h.p. DC motor.

help full automation HERE!

Automated machines require three basic characteristics in their operating components—and particularly in their clutches and brakes.

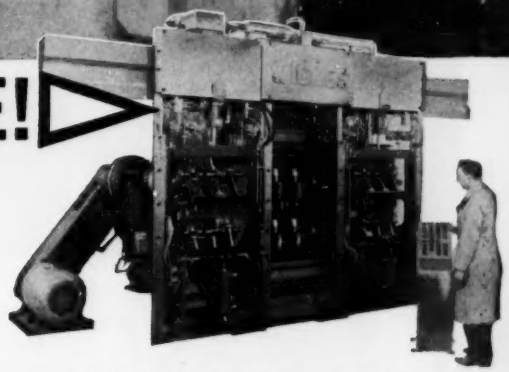
First, they must provide instant response to electric or electronic controls, with full-power torque output for all work done by the machine.

Second, they must produce shock-free precision starts and stops for accurate cycling of the machine and the work.

Third, they must provide long maintenance-free operating life with automatic adjustment for operating wear.

For these and other inherent advantages, FAWICK Airflex Clutches and Brakes are used on Wickes MX-4 Crankpin Lathes. This outstanding full-automatic multi-stage machine is used to turn crankpins, and to "cheek" counterweights to the shoulder diameter of crankpins—with both operations carried out simultaneously on two crankshafts.

FAWICK Airflex products can improve your machine performance. For full information on the advantages they offer call or write your nearest FAWICK representative or the Home Office, Cleveland, Ohio.



Wickes Model MX-4 Crankpin Lathe is used for automatic turning of crankpins, and "cheeking" of counterweights in simultaneous machining of two crankshafts.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
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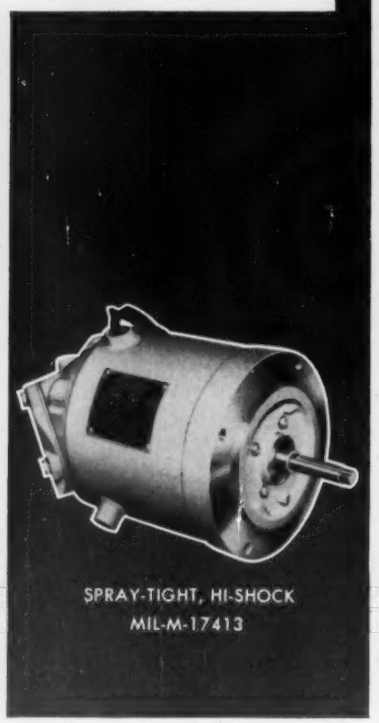
FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

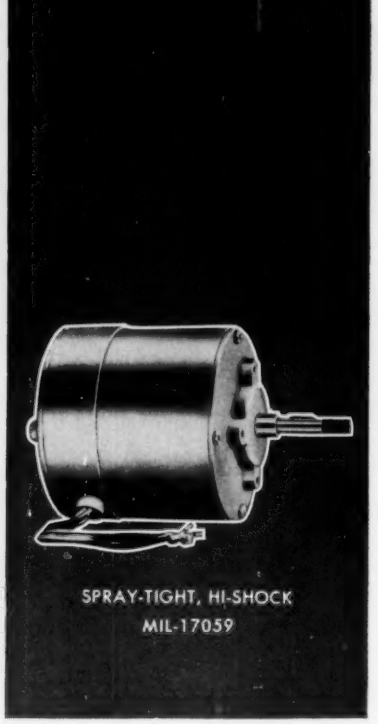
Circle 445 on Page 19

Military Motors

SPRAY-TIGHT, FAN COOLED,
HI-SHOCK
MIL-M-17060A



SPRAY-TIGHT, HI-SHOCK
MIL-M-17413



SPRAY-TIGHT, HI-SHOCK
MIL-17059

These Peerless motors meet all critical military codes. Spray-Tight Service "A" units withstand tremendous shock, high vibration levels and great temperature changes.

The Peerless military motor is available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from ½ to 30 HP.

All motors meet specifications of ABS, U. S. Coast Guard, MIL-M-17413 (DC), MIL-M-17060A and 17059 (AC), AIEE 45 and radio interference. With standard or special mountings and features, they serve at land-based radar installations and aboard vessels throughout the world.

Give us your military motor problem. We'll work with your engineers to produce the motor which serves your needs best and meets the particular military specifications involved.

ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

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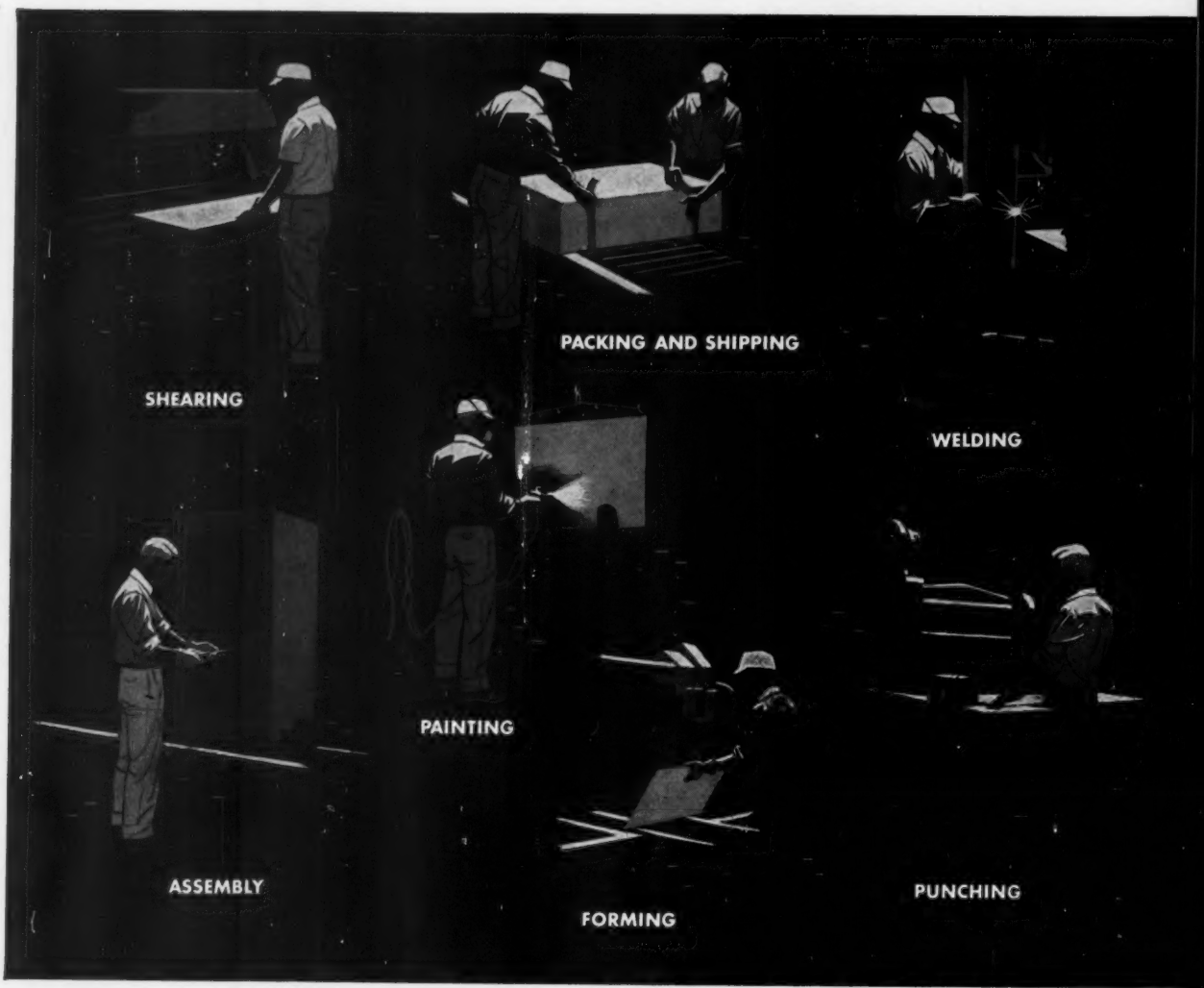

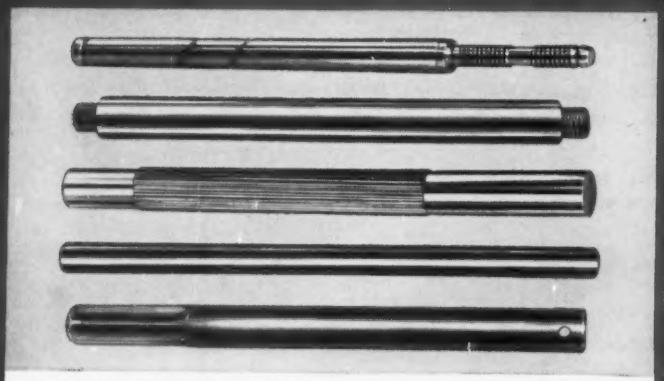

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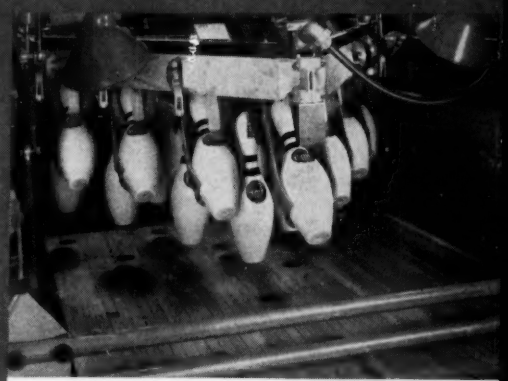

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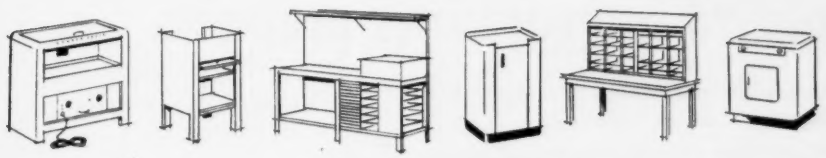
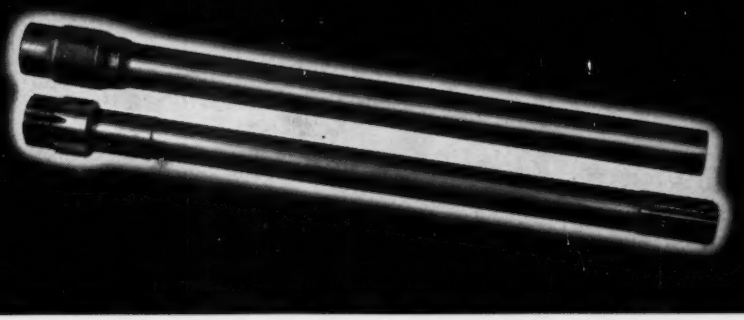
Berger Division complete sheet steel fabrication know-how and facilities may be the answer to your assembly-production problems. To learn more about Republic-Berger contract facilities, call or write today.



CALL YOUR REPUBLIC REPRESENTATIVE OR WRITE...



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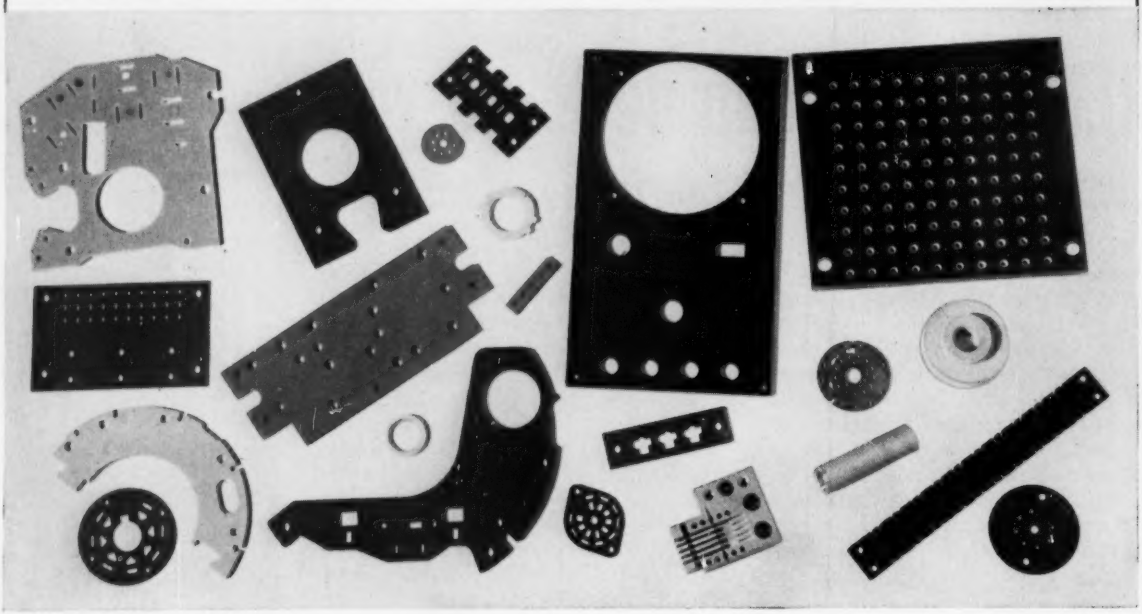

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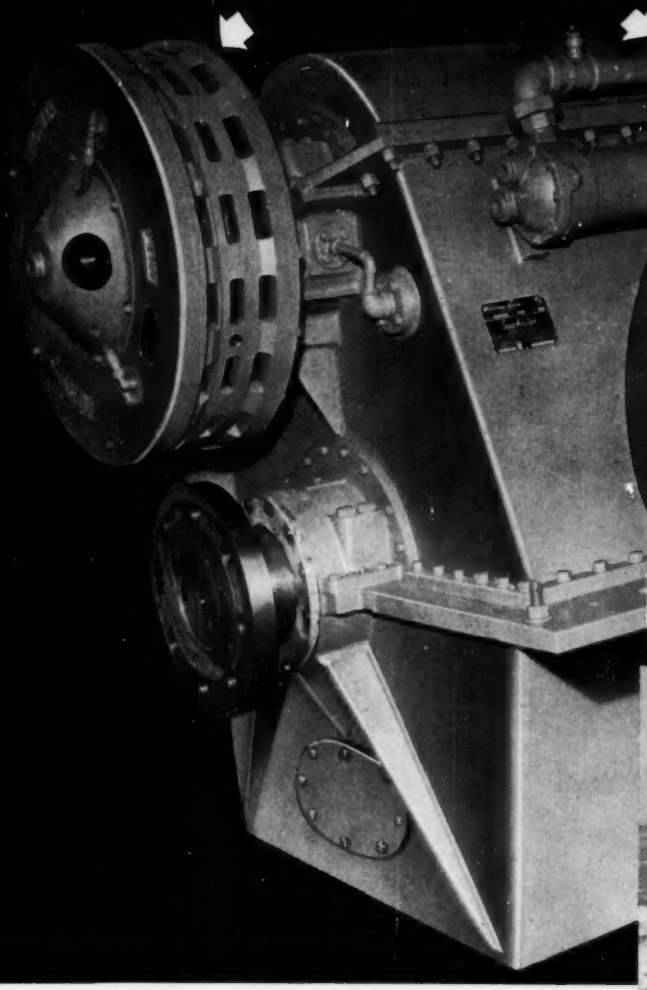
GENERAL ELECTRIC

One of these Certified Textolite Fabricators can give you expert service and fast, local delivery on fabricated Textolite parts:

Ohio—Michigan—Pennsylvania: Jaco Products Co., 2150 St. Clair Ave., Cleveland 14, O.; M. L. Parker Co., 8699 West Chicago Ave., Detroit 4, Mich.; Earl B. Beach Co., Verona Rd., Pittsburgh 21, Pa.; Vernon Montage Co., Route 3, Butler, Pa.; Stahlin Bros. Fibre Works, Belding, Mich. • ***New England:*** Emmco Plastics Fabricators Co., 68 Vine St., Everett, Mass.; Insulating Fabricators of New England, Inc., 69 Groove Street, Watertown 72, Mass.; Hampden Manufacturing Co., Three Rivers, Mass.; Plastic Fabricators, Inc., P. O. Box 32, West Franklin, N. H.; Insulation Products Co., 7 Springfield St., Chicopee, Mass.; Electronic Plastics Corp., 16 New Salem St., Wakefield, Mass.; Laminated Sheet Products Corp., 449 Neponset St., Norwood, Mass.; Universal Products, Inc., 224 North Montello St., Brockton, Mass. • ***Upstate New York:*** Rochester A & B Co., 1378 East Ridge Rd., Rochester 21, N. Y.; Precision Fabricators, P. O. Box 230, West Commercial St., East Rochester, N. Y. • ***New York-New Jersey:*** Comco Plastics, 98-34 Jamaica Ave., Richmond Hill 18, N. Y.; Electrical Insulation Co., Inc., 1245 Marconi Blvd., Copiaque, L. I., N. Y.; Insulating Fabricators, Inc., 150 Union Ave., East Rutherford, N. J.; Insulating Specialties, Inc., 15-19 Evans Terminal Rd., Hillside, N. J.; Thomas J. Long, Inc., 2150 Stonehinge Lane, Carle Place, L. I., N. Y.; Sheffco Manufacturing Corp., 323 Bergen Blvd., Fairview, N. J. • ***Middle Atlantic:*** Engineered Plastics, Inc., P. O. Box 508, Gibsonville, N. C.; Earl B. Beach Co., 1609 Vine St., Philadelphia 3, Pa.; Penn Fibre & Specialty Co., 2024 E. Westmoreland St., Philadelphia 34, Pa.; Brandywine Fibre Products Co., 15th & Poplar Sts., Wilmington, Del. • ***Ohio Valley:*** Aqua Sportsman, Inc., 2518 Leslie Ave., Cincinnati 12, O.; General Rubber & Supply Co., 3118 S. Preston Hwy., Louisville, Ky.; Hersh Packing & Rubber Co., 72 Jennings Ave., Canal Winchester, O. • ***Texas:*** A & A Supply Co., 1839 Levee St., Dallas, Texas • ***Chicago:*** Permonite Manufacturing Co., 910 West Jackson Blvd., Chicago 7, Ill.; Micarta Fabricators, 5324 Ravenswood, Chicago, Ill.; Precision Phenolics, 10031 Franklin Ave., Franklin Park, Ill.; Jetron Mfg. Co., 1665 Milwaukee Ave., Chicago, Ill.; Fibre Fabricators, Inc., 4540 W. Addison St., Chicago 41, Ill.; Mandex Mfg. Co., 2614 W. 48th St., Chicago 32, Ill. • ***West Coast:*** Plasti Parts, 2774 E. Walnut, Pasadena, Calif.; Conroy & Knowlton, 2315 Ripple St., Los Angeles 39, Calif.; Superior Plastics, 141 Arena, El Segundo, Calif.; Accurate Electronics (copper clad), 13215 Ledwell, North Hollywood, Calif.; Packard Bell (copper clad), 12333 W. Olympic Blvd., Los Angeles, Calif., Eclipse Engineering Corp. (copper clad), 3046 Fletcher Drive, Los Angeles 65, Calif.; Kennedy Plastics, 335 S. State St., Alhambra, California • ***Wisconsin-Minnesota:*** Midland Plastics, Incorporated, 221 N. Water St., Milwaukee, Wisconsin; Asbestos Fabricators, Incorporated, 5042 W. State St., Milwaukee, Wisconsin; Bureau of Engraving, Incorporated, 510 S. 4th Street, Minneapolis 15, Minnesota; Federal Tool & Die Company, 3600 Alabama Avenue, Minneapolis, Minnesota.

WICHITA CLUTCHES . . . TEAM WITH NEW WESTERN SEA MASTER REVERSE AND REDUCTION GEAR . . .



Provide
EXTRA DEPENDABILITY
Plus
LOW MAINTENANCE,
SMOOTH OPERATION
and
FAST MANEUVERABILITY
for tug "Carolyn"

Wichita Clutch's outstanding performance and adaptability does it again . . .

Combination of Wichita Air-Tube Disc Clutches and Western's new Sea Master Gear design raises the standards of marine operation by reducing maintenance to a minimum, and providing smooth operation and fast maneuverability.

Dependability and flexibility of the application of Wichita Air-Tube Clutches and Brakes have made them extremely popular among design engineers in nearly every industry. Call your nearest Wichita Clutch dealer for prompt assistance on any clutching or braking problem.

Contact your nearest Wichita Engineer!

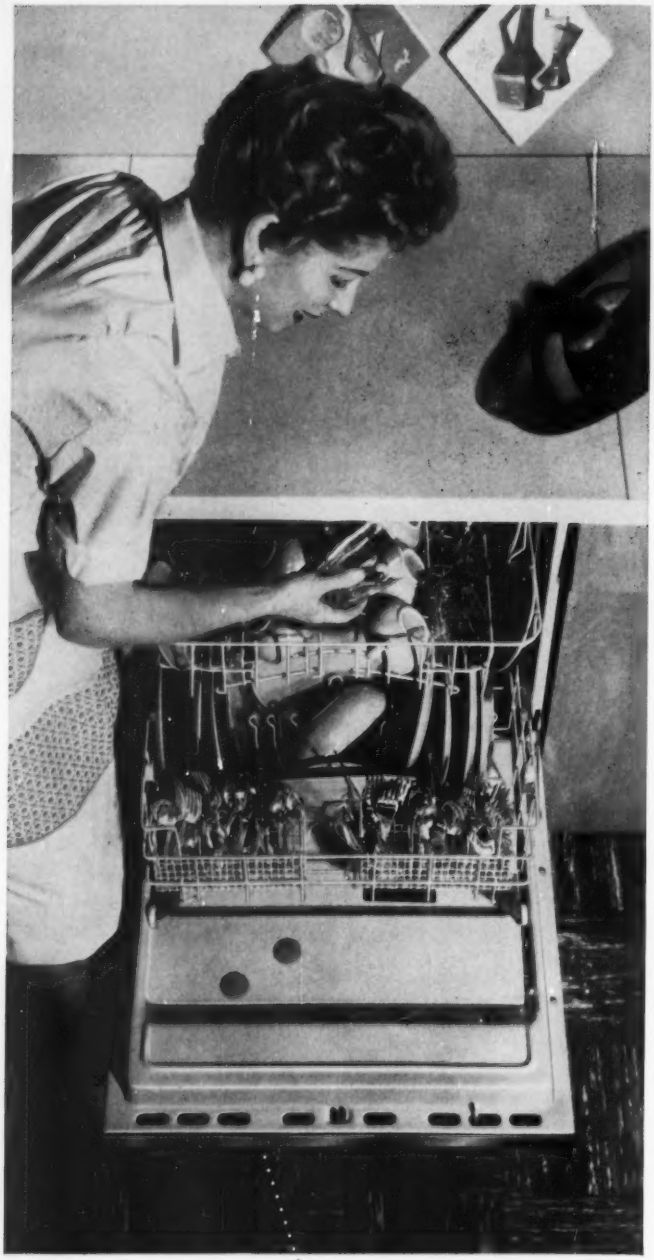
Clutch & Control Engineering Co., Livonia, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Circle 450 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Here's the Inside Story...

dishwashers wear a coat of Geon

The tub, door lining, and racks of this new dishwasher are coated with a soft, resilient, and colorful Geon polyvinyl material. It treats housewives—and their dishes—more kindly than ever before. Yet it is tough and abrasion resistant—tests show it will outlast other coatings by two to three times.

The lining acts as an extra barrier to heat, moisture and sound. It will not crack, chip or peel—or become tacky or embrittled. It resists corrosion and stands up well to heat, light and aging. If damage should occur, the coating can be repaired quickly and easily by servicemen in the field.

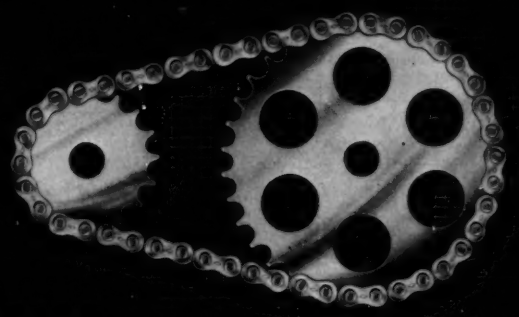
Geon polyvinyl materials are being used for many kinds of coating applications—from metal and glass, to paper and textiles. Geon is a versatile material and is available in many forms for servicing many industries. Rigid vinyl pipe, electrical insulation, house siding and coated steel paneling are only a very few of the many products Geon serves so well. For help on your product idea, write Dept. AS-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

New automatic dishwasher-dryers manufactured by Waste King Corporation, have a tough, resilient, and colorful lining formulated by Michigan Chrome & Chemical Company, Detroit. B.F.Goodrich Chemical Company supplies the Geon polyvinyl material.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers



World's smallest
bushing-type chain | .1475″ pitch

NEW DIAMOND *Micropitch*

for miniature
and sub-miniature devices . . .

Precision-built of non-magnetic
Stainless Steel

DIAMOND *Micropitch* is the first extremely fine pitch bushing chain (.1475″) made especially for small-space applications such as cameras, computers, recorders, data processers and many other devices using miniaturized movements. It is ideal for power transmission, synchronization or conveying . . . and conforms to the same high standards of quality that have characterized all DIAMOND chains for more than 69 years.

You are invited to utilize DIAMOND'S *wealth of roller chain experience. Write for engineering recommendations for your project. Please supply complete details.*

DIAMOND CHAIN COMPANY, INC.

A Subsidiary of American Steel Foundries

Dept. 435 • 402 Kentucky Ave., Indianapolis 7, Indiana

OFFICES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

DIAMOND ROLLER CHAINS

SPECIFICATIONS

Pitch	.1475″
Overall Width	.210″
Weight per Foot (Approx.)	½ oz.
Chain length	+.051″ to −.000/ft.
Operating Temp.	−65°F. to +400°F.
Tensile Strength	180 lbs. Average
Material	18-8 SS non-magnetic grade

Available also in ¼″ Pitch, ASA No. 25 in stainless steel or standard steel.

SPROCKETS—Made to your specifications in regular or stainless steel, bronze, aluminum, nylon or other materials.

CONSTRUCTION FEATURES—Large joint bearing areas • High order press fits • Precise chain length control • Corrosion resistant, non-magnetic stainless steel.

ADAPTABILITY

Permits wide variety of shaft centers. • Multiple shaft drives can be accurately timed • Sprockets may engage both sides of chain • Connecting links easily assembled or disassembled without removing sprockets.

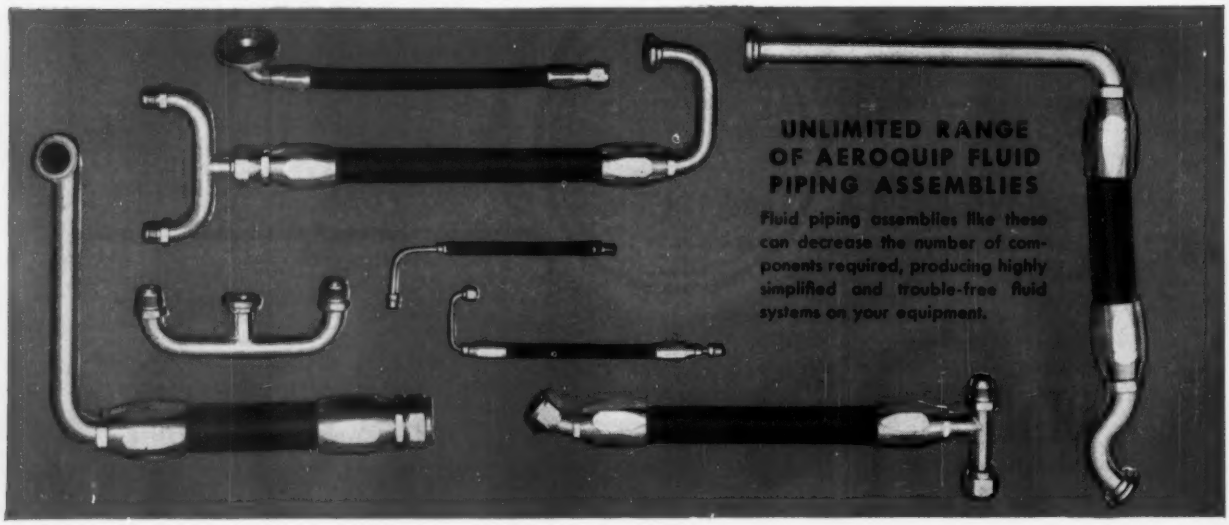
CONVEYOR CHAIN

On special order, DIAMOND *Micropitch* chain can be supplied for small conveyors in elongated pitch construction and with special attachments.

Circle 452 on Page 19

How Aeroquip Fluid Piping Service Can

Experienced Aeroquip personnel work closely with your parts or service department personnel to develop a program which meets your precise requirements. It includes parts simplification, part numbering, interchange data, cataloging and technical assistance.



UNLIMITED RANGE OF AEROQUIP FLUID PIPING ASSEMBLIES

Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

Simplify Your Service Parts Program

AEROQUIP BULK HOSE AND REUSABLE FITTINGS THAT CAN BE FIELD ASSEMBLED REDUCE INVENTORY, SIMPLIFY ORDERING, STOCKING AND HANDLING

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Fluid piping service parts program costs can be reduced substantially and the whole program simplified when you use Aeroquip fluid piping components—bulk hose and reusable fittings.

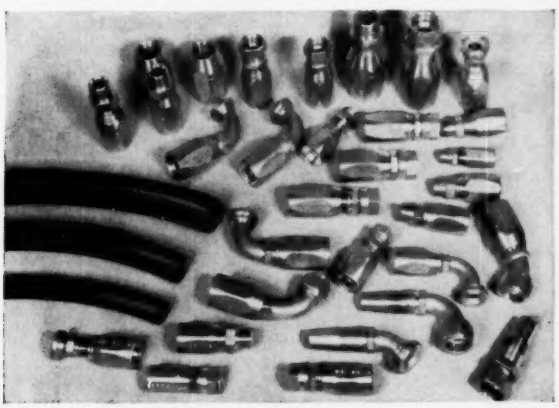
You, your distributors and dealers actually deal with fewer parts. After standardizing on Aeroquip components, one major equipment manufacturer, for example, is now able to fill orders for more than 400 production assemblies from only 3 hose part numbers and 34 fitting part numbers.

These fewer part numbers mean:

1. Greatly reduced paperwork needed for ordering, inventory control and invoicing, save many valuable man-hours.
2. Less required investment in parts inventory and a faster turnover of stock, for both you and your service parts organization.
3. Less space is required to handle the same volume of service.

Aeroquip is able to assist you in your fluid piping parts program. This assistance includes promotion of the program and its opportunities for dealer profits to your distribution organization. It also includes assistance in instructing dealers and field service representatives on use of Aeroquip fluid piping components.

Service parts program simplification is one of the five basic aids in Aeroquip's Fluid Piping Service that extends from fluid system design, through prototype development, production assistance and field service. For complete details, fill in and mail the coupon below.



A good example of parts simplification, this modest inventory display fulfills the requirements for hundreds of original part number replacements.

Your dealers and distributors will value the savings in inventory dollars and space made possible by standardizing on Aeroquip Bulk Hose and Reusable Fittings.

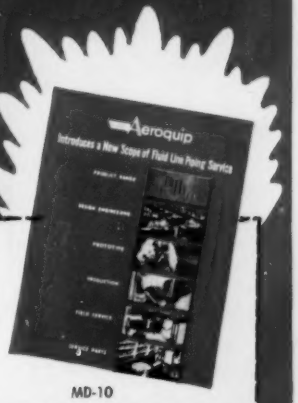
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



MD-10

Special Literature Available

Aeroquip Corporation, Jackson, Michigan

☐ Please send me a copy of Bulletin 614 explaining your complete service of fluid system design and performance.

☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

Name_____

Title_____

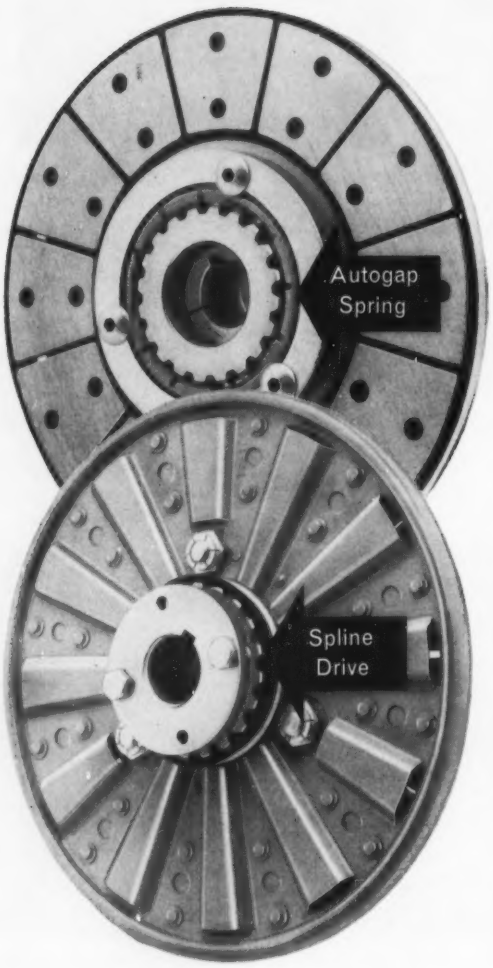
Company_____

Address_____

City_____ Zone____ State_____

Circle 454 on Page 19

NEW SPLINE-DRIVE ARMATURE



for Warner electric brakes and clutches ... reduces maintenance and assembly costs

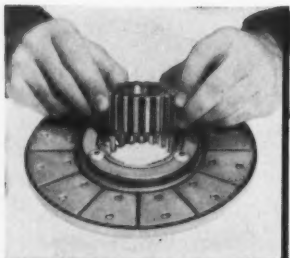
Now, you can reduce maintenance downtime, speed assembly, prolong armature life, and make heavy-duty, high-cycle machinery more automatic—more productive.

Warner's new armature drive provides greater bearing area, distributes heavy shock loads evenly over multiple involute splines, virtually eliminates wear, and increases armature life.

Easy assembly and fast alignment reduce installation cost. (See illustrations below.) Sliding fit between mating hub and adapter lets armature creep axially, compensating automatically for wear. Patented one-piece autogap spring maintains a constant air gap when magnet is de-energized—assures efficient, snap-action release.

Spline drive armatures are available from stock for use with Models 825, 1000, 1225, and 1525 Warner electric brakes and clutches.

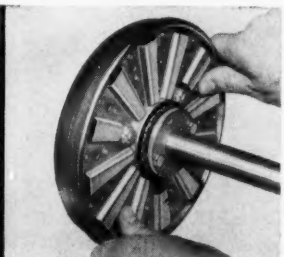
To learn more about these rugged, low-cost drives for high-cycle applications, write for Bulletin P-68.



1 Unique design speeds mounting and alignment, cuts assembly costs. Spline drive distributes load, reduces wear, increases armature life.

2 With splined hub in place, tapered bushing is inserted in armature assembly and bushing holes aligned with tapped holes in splined hub.

3 Complete armature is mounted on shaft and placed in contact with magnet face. Tightening capscrews locks armature assembly to shaft.



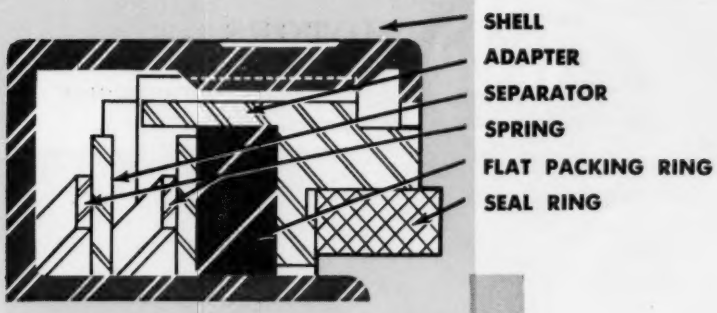
4 One-piece autogap spring automatically aligns assembly when armature is pushed against magnet and released.

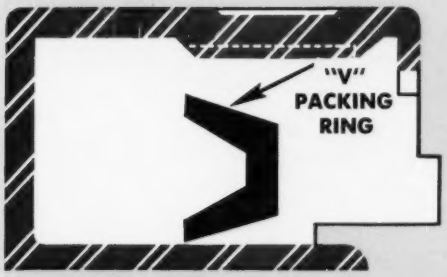
WARNER

Warner Electric Brake & Clutch Company
Beloit, Wisconsin

Circle 455 on Page 19

GITS HH-TYPE SEAL SERIES





VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 456 on Page 19

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

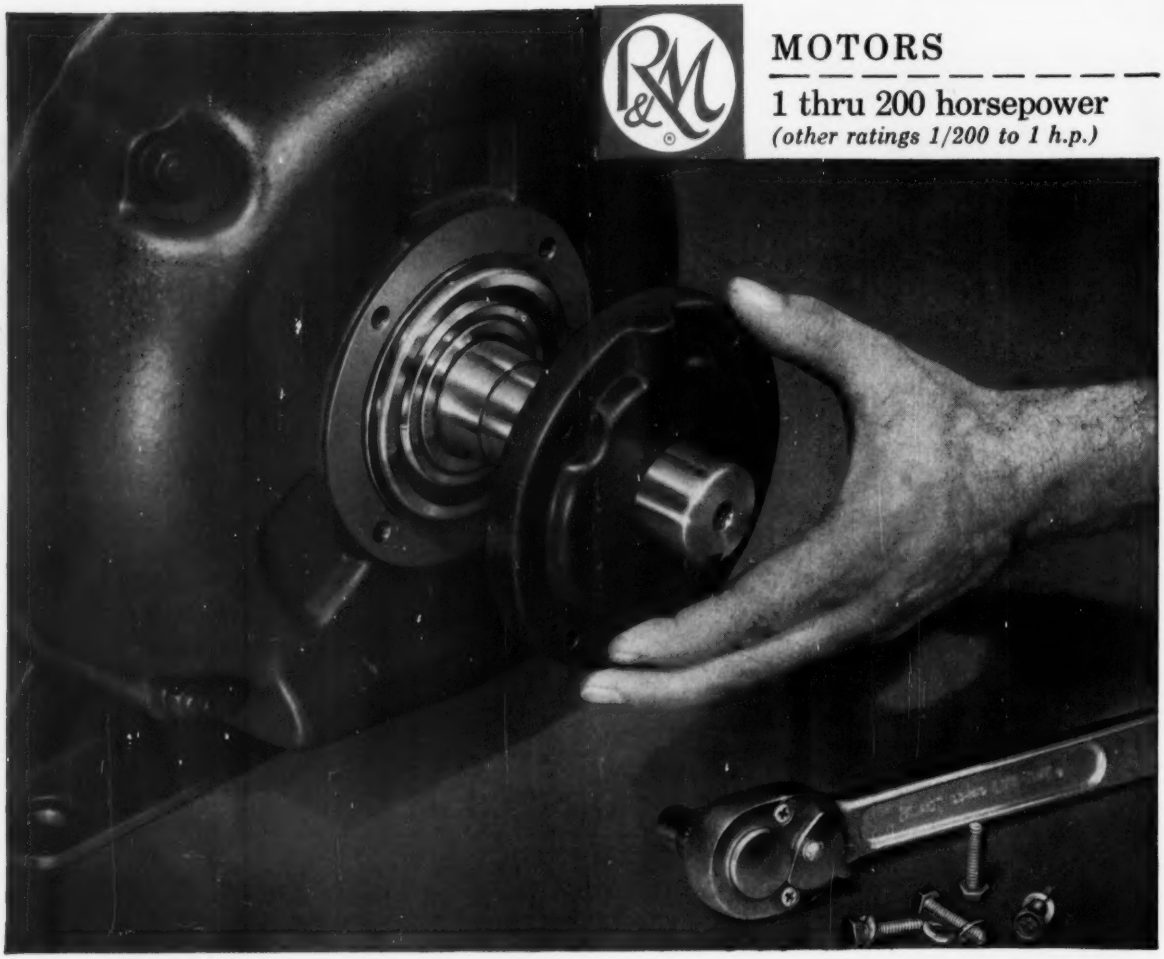
The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

GITS BROS. MFG. CO.

1868A South Kilbourn Avenue • Chicago 23, Illinois

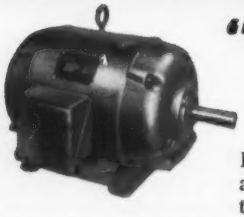
NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

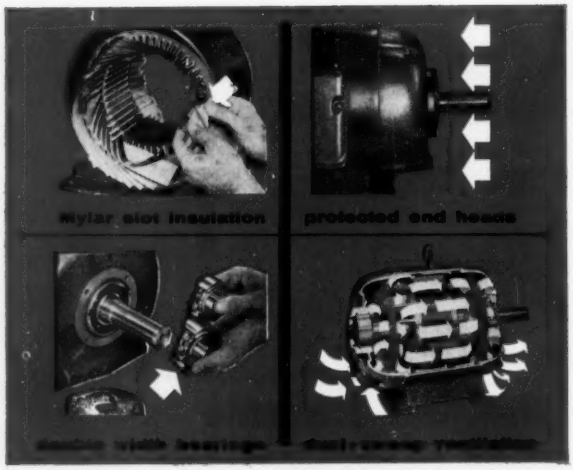


"On-the-Job" Bearing Inspection and Relubrication are Easy!

ROBBINS & MYERS motor bearings are fully sealed and pre-lubricated to operate for years without attention of any kind. However, when maintenance schedules call for bearing inspection and relubrication at shorter intervals, R&M motors cut downtime and save labor expense by making these inspections easy. The bearing cap on each end head comes off quickly when the four securing bolts are removed. The bearing seal, held in place by removable snap rings, likewise, is easily removed to expose the interior of the bearing.

Easily removable bearing caps are only one of R&M's many desirable design features. Double width bearing races have extra-large grease capacity . . . Mylar® insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . end heads offer full-height protection . . . dual-sweep ventilation assures efficient cooling. For details, write today for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 456 on Page 19

DU PONT VITON® SYNTHETIC RUBBER

NOW PROVEN IN PERFORMANCE WITH OILS, FUELS, SOLVENTS, CHEMICALS...TEMPERATURES OVER 400° F.

Well over a year ago, Du Pont, a pioneer in synthetic rubber research and development, introduced VITON, a fluoroelastomer with an impressive combination of properties.

Engineers engaged in the design of aircraft, autos, appliances, chemical and industrial equipment were quick to evaluate this new synthetic rubber for use in their own designs.

Today, the improved operation of a wide range of industrial products can testify to VITON'S success. Just as the laboratory reported, VITON *is* resistant to heat . . . in certain critical applications as high as 600°F. And its fluid resistance has been *proved* by a host of commercial applications involving oils, fuels, solvents and corrosive chemicals.

If you haven't already received full information on VITON, write for our new booklet. It outlines the important design properties and details some of the interesting applications that have been found for this new elastomer. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MD-10, Wilmington 98, Delaware.

Typical Commercial Applications Where VITON Now Means Better Product Performance

PRODUCT	OPERATING CONDITIONS
Aircraft Fire Seals (coated asbestos type)	Aviation fuel, hydraulic oils, 500° F. temperatures, ozone
Appliance Shaft Seals (washer-drier)	Detergent solutions, grease, hot air at 300° F.
Carburetor Parts	High aromatic content gasolines
Centrifuge Seals	Chlorinated hydrocarbons including methylene chloride
Heat Exchanger O-Rings	Fatty acids at 525° F.
Oil Well Packer Seals	Crude oil at 6000 psi, 300° F.
Pump Diaphragms	Concentrated sulfuric acid
Pump Liners	Concentrated hydrochloric acid
Safety Suits	TEL and missile fuels
Stove Thermostat Diaphragms	Heat expansible fluid at 400° F.
Valve Seats and O-Rings	Benzene, toluene, xylene, 400° F. propane
Valve Stem Seals	Hot automotive lubricants

DU PONT REG. U. S. PAT. OFF. SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON®
ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

Circle 458 on Page 19

In 1946 J. Gordon Lippincott and Walter Margulies began what has proved to be one of the nation's most successful industrial design firms. Here their firm has chosen the new, exciting patterns of Sharonart* as the material for their advanced design room air conditioners.

Eliminating the conventional box-like unit Lippincott & Margulies have taken advantage of the principle of thermoelectric refrigeration and the beauty of Sharonart* to design units that are both attractive and functional. Fans, housed in the base or back of these units, force air over the cooling elements and circulate it throughout the room. Housings of perforated and painted or plated Sharonart* give the units added beauty while practically eliminating wear.

Tomorrow's room air conditioners designed by Lippincott and Margulies with SHARONART*

Patterned Steel

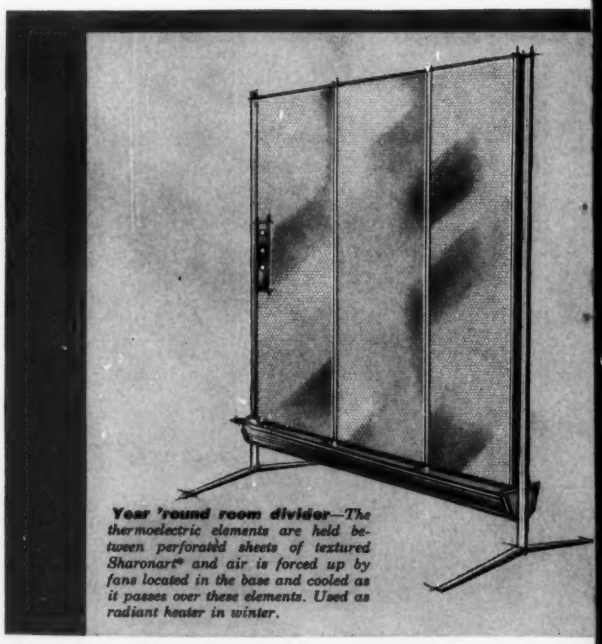
Sharonart* . . . the greatest advance in design steels in a decade . . . brings unequalled versatility to product engineers. Virtually any pattern can be rolled into one or both surfaces of stainless or carbon steels. It can then be fabricated as easily as plain steel . . . perforated, drawn, roll formed, stamped with few limitations. It can be painted, plated or coated by standard methods.

Here's new beauty, new style for your product without expensive retooling. Here's the ideal material for wear areas for most Sharonart* patterns hide scratches, fingermarks, etc.

Sharonart* is available in big production coils in a wide range of gauges and widths. Get the complete story, write for literature today.

Sharon Steel Corporation, Sharon, Pa.

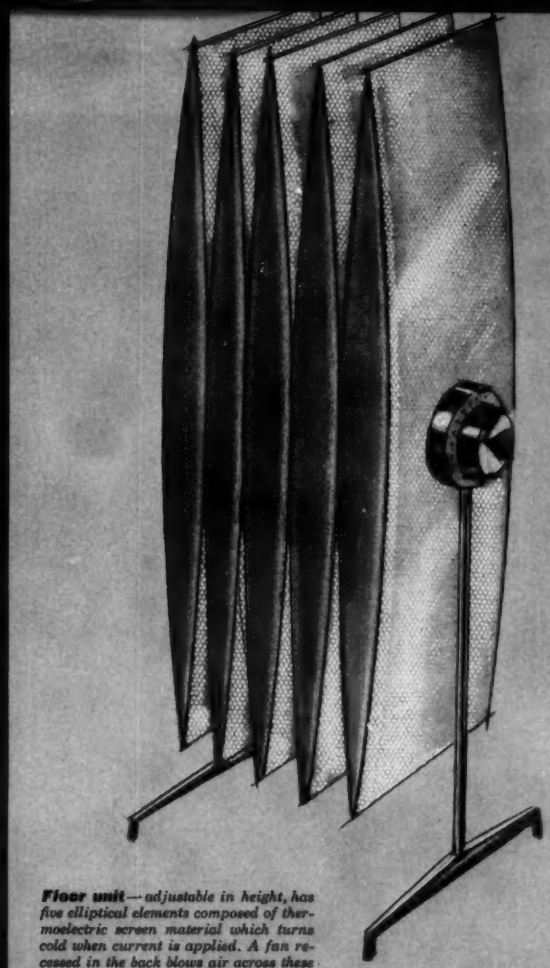
*TM



Year 'round room divider—*The thermoelectric elements are held between perforated sheets of textured Sharonart* and air is forced up by fans located in the base and cooled as it passes over these elements. Used as radiant heater in winter.*

Circle 459 on Page 19

SHARONSTEEL **SHARON** *Quality* **STEEL**



Floor unit—adjustable in height, has five elliptical elements composed of thermoelectric screen material which turns cold when current is applied. A fan recessed in the back blows air across these elements and circulates it throughout the room. Housing of Sharonart® reduces wear, adds beauty.

Portable unit—Star shaped form on top is the refrigeration element and air is forced up by a centrifugal fan located in the base of the unit. Sharonart® is used in both tower and ring.

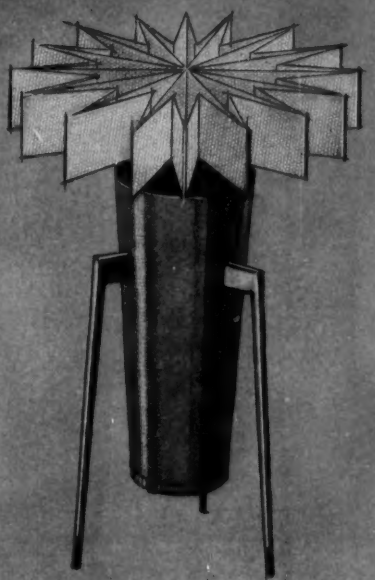
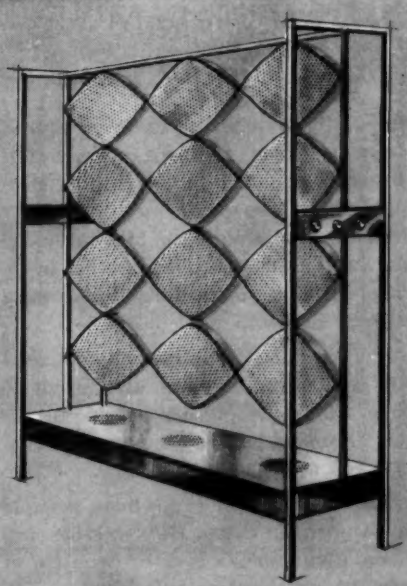
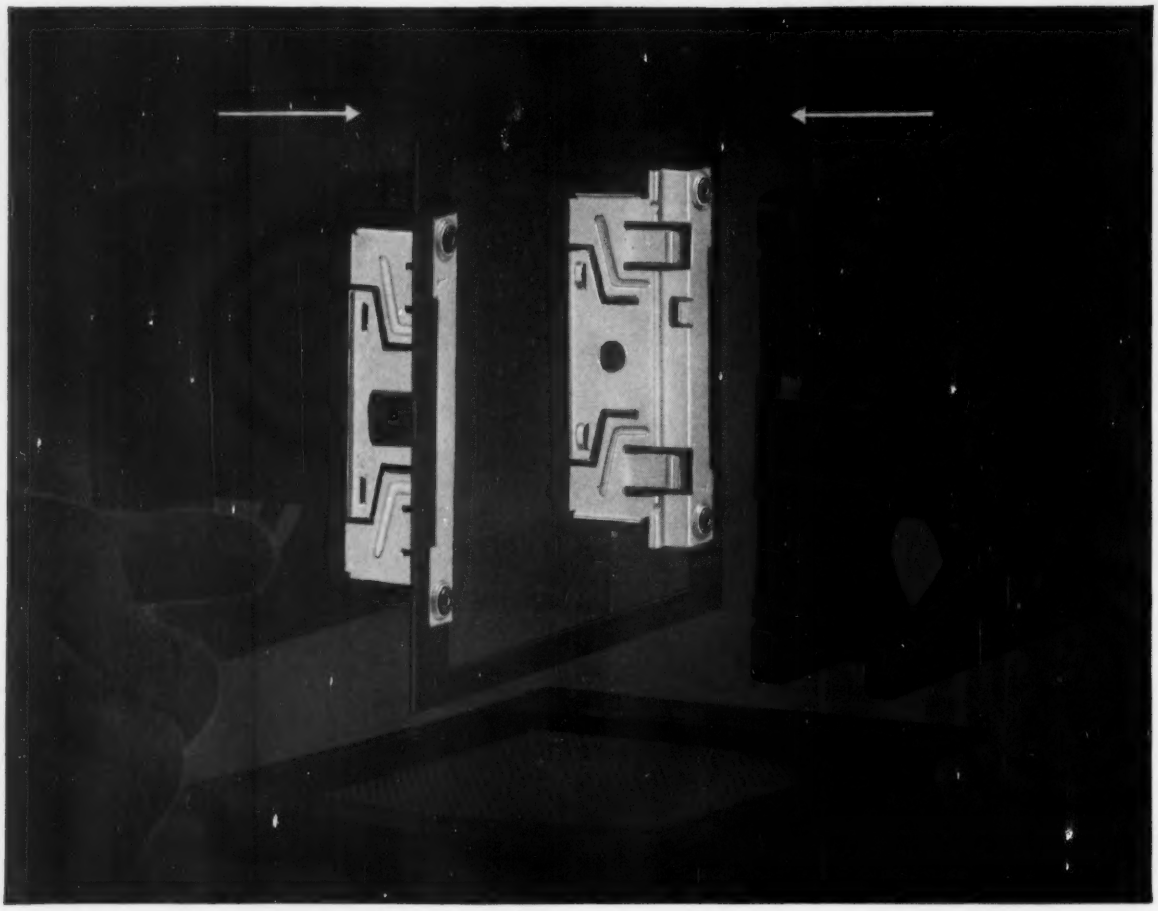


Table unit—The upper half is made up of a thermoelectric element and air is blown up and through by a centrifugal fan mounted in the base. A removable pan is provided to collect any moisture which may form on the sides. Fins and base of contrasting patterns of Sharonart®.



Decorative room divider—Perforated Sharonart® provides unlimited design possibilities for large room units. Thermoelectric units are contained in perforated Sharonart® housings, fans in base of harmonizing Sharonart® pattern.



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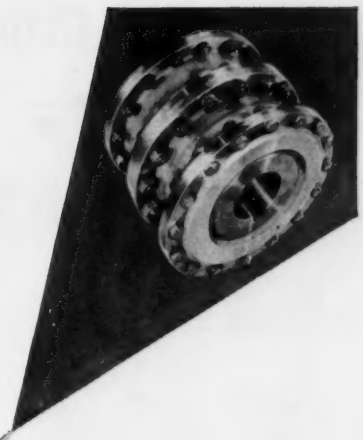

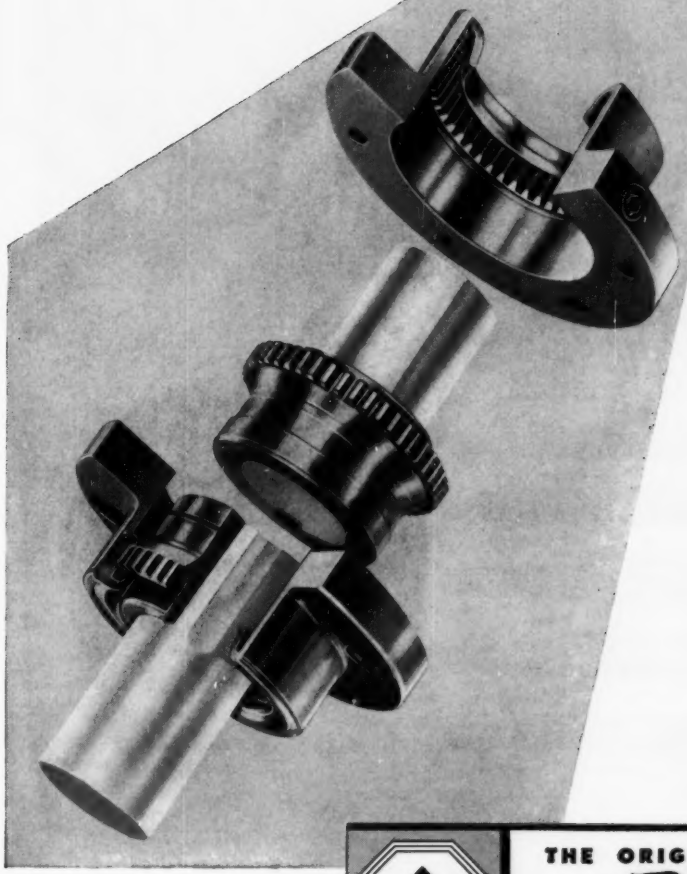

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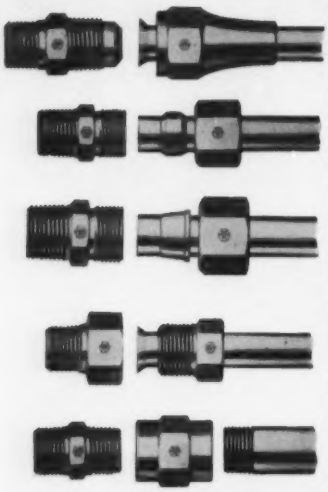

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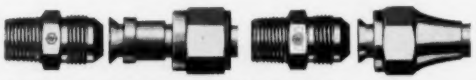

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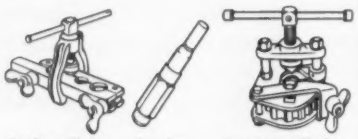

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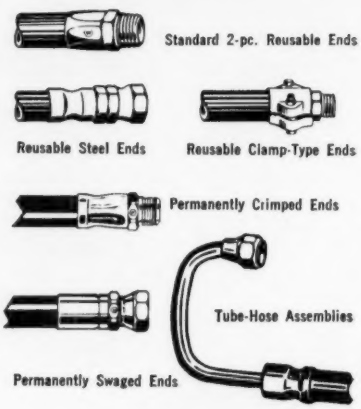

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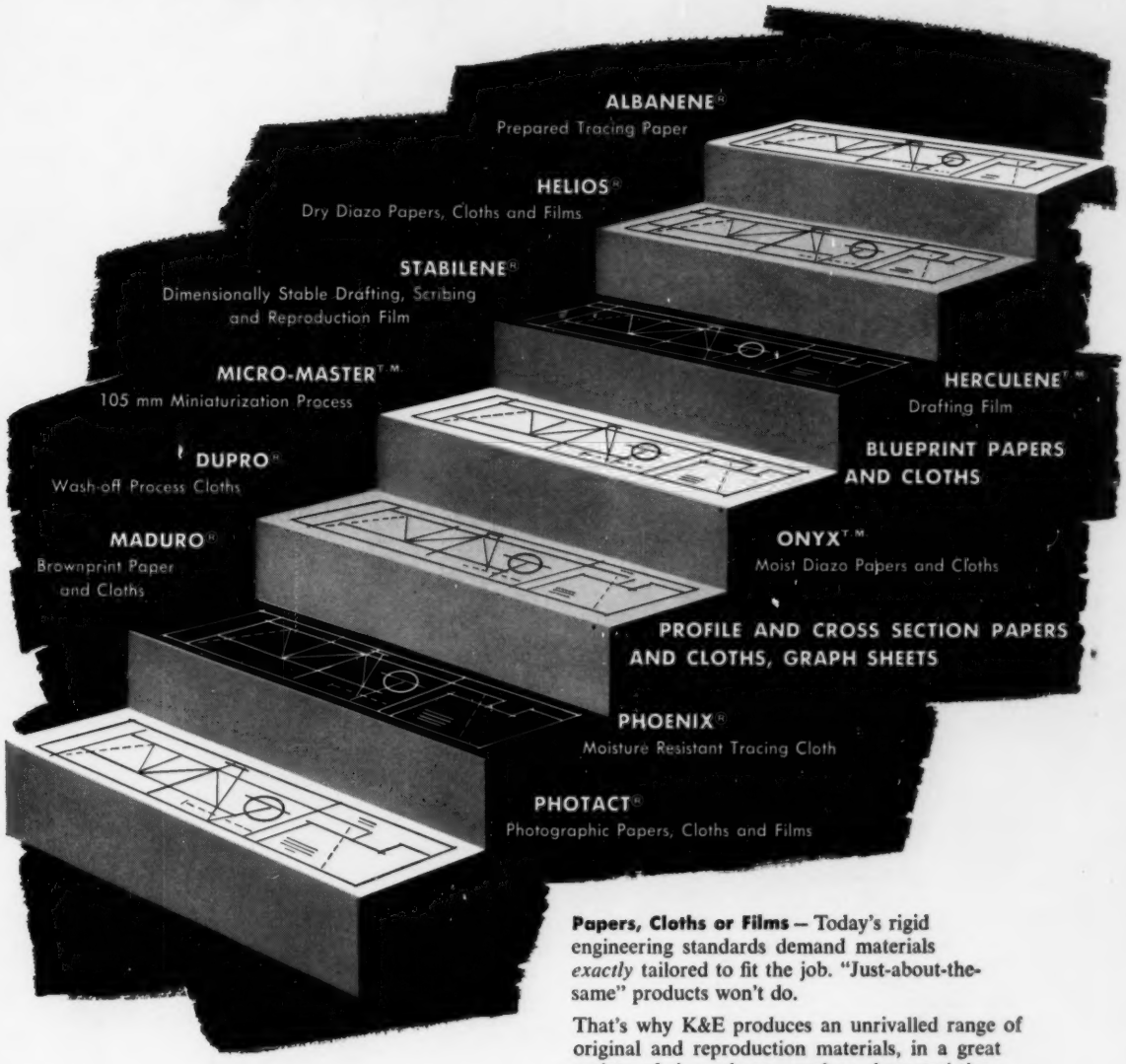

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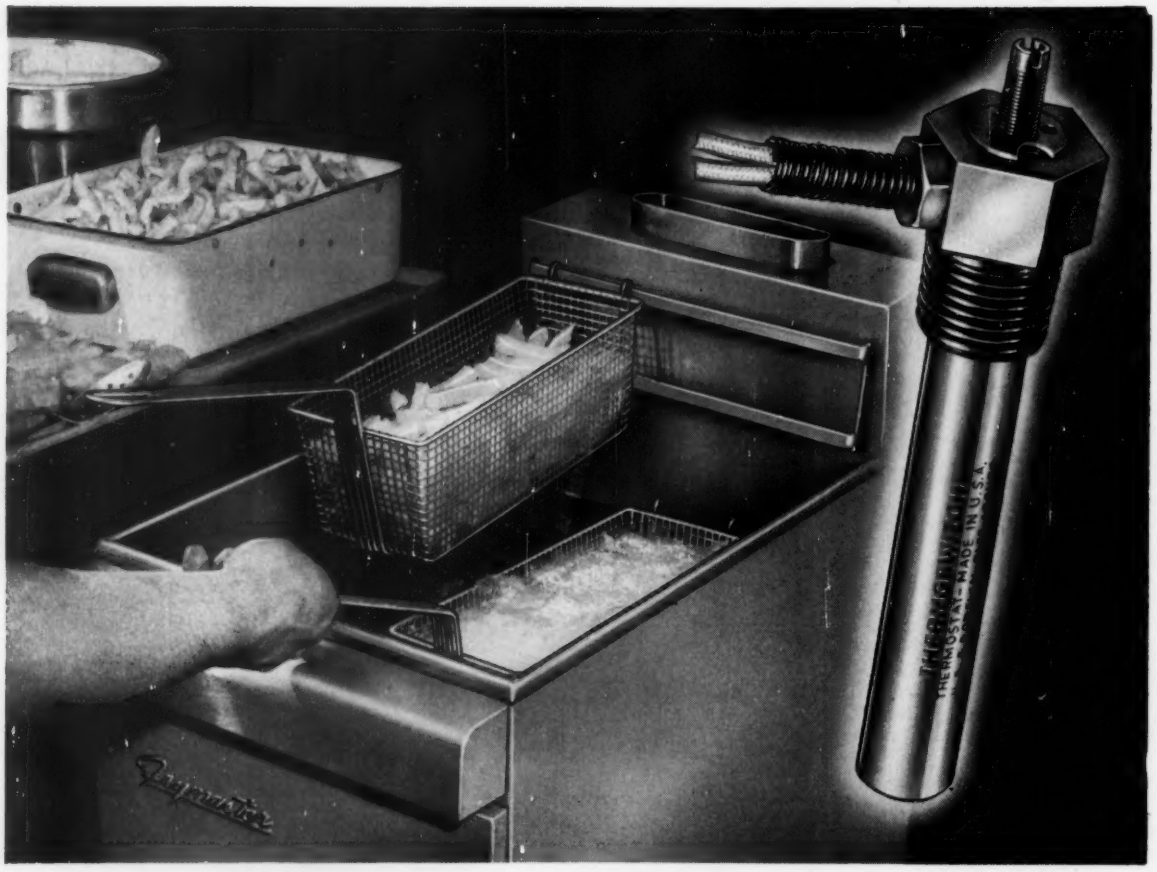
This is our 17000 series (we've got 25,000 other variations with the operating ranges from −100°F to 600°F) in use in Master Jet Frymaster. The Fenwal control gives the machine rapid, precise response; greater reliability — even makes it more economical by conserving cooking fat and gas!



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

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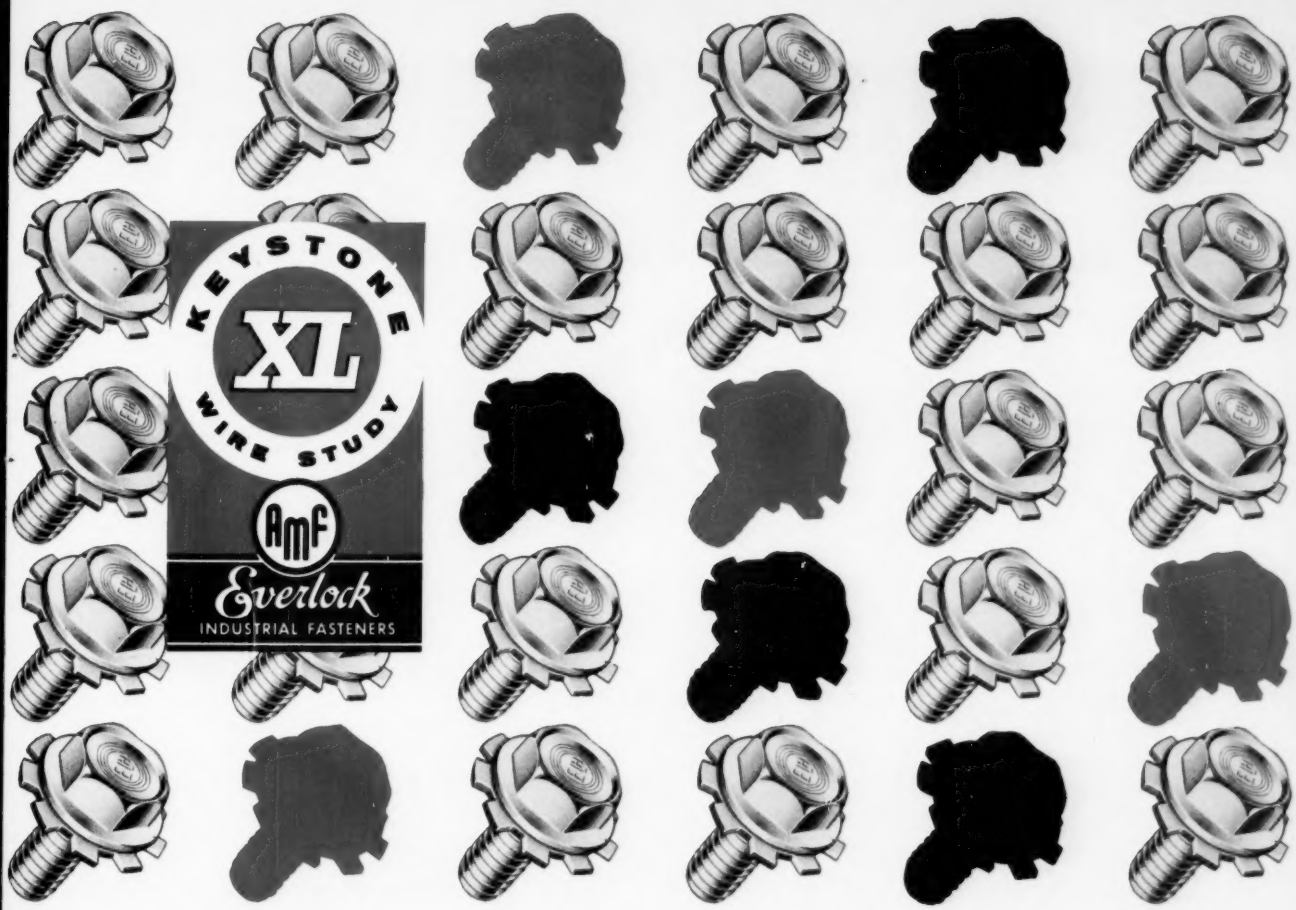

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It takes 10,371 of the smallest cups to weigh a pound and they are 20% lighter than the ones formerly made from drawn steel. Each is precision die cast to a remarkable degree of uniformity and accuracy, despite the complex design.

Such extremely thin-wall sections—possible only with zinc die castings—**frequently eliminate competition from all other materials and production methods.** In addition, ZAMAK zinc die castings provide many more advantages —and all at lower cost.

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HORSE HEAD PRODUCTS®

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MACHINE DESIGN
October 29, 1959

A Cure for Frustration

AT HIS first rehearsal with a new orchestra, the guest conductor was disturbed to notice strong signs of unhappiness on the face of one of the players. Unable to stand it any longer, he laid down his baton and addressed the suffering man: "Don't you like my conducting?" That wasn't it. "Maybe you don't like Stravinsky?" That wasn't it either. "Well, then, what *is* the trouble?" "It's just that I don't like music."

An aspect of professionalism that isn't stressed in the various high-sounding definitions is the requirement of enthusiasm for the job. The engineer who, deep in his heart, doesn't like engineering will never be a great engineer, any more than the frustrated orchestra player will ever be a great musician.

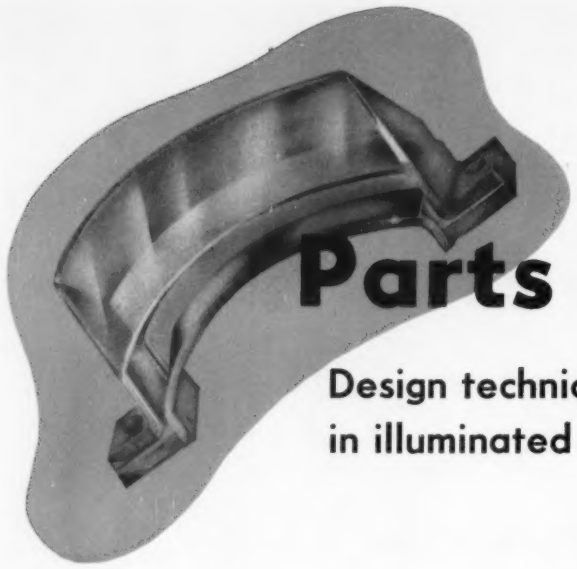
An editorial in a recent issue of *The Western Electric Engineer* suggests a course of action for the engineer who considers his job to be a major source of frustration and discontent. It is to increase his "total participation" in engineering —against his own inclination if necessary. This means throwing himself heart and soul into off-the-job professional activity as well as job-connected work.

Result will be a new sense of achievement for its own sake and an upward adjustment of personal aspirations. Almost certainly this will lead to improved performance, followed by recognition and reward. But, the editorial goes on to point out, this increased personal participation just might serve to confirm the engineer's frustration and discontent. In that case it is obviously high time for him to seek some other way to earn a living.

Until the plunge has been taken, nobody really knows how cold the water is—for him. Dabbling at the water's edge is a poor guide. And engineering is no place for dabblers, either. The life of the engineer, like that of any other true professional, has to be what Walt Whitman called "a life that shall be copious, vehement, spiritual, bold."

Colin Carmichael

EDITOR



Parts That Glow

Design techniques for controlling light in illuminated acrylic plastic parts

A. M. BLUMENFELD and S. E. JONES
Design Staff
Rohm & Haas Co.
Philadelphia, Pa.

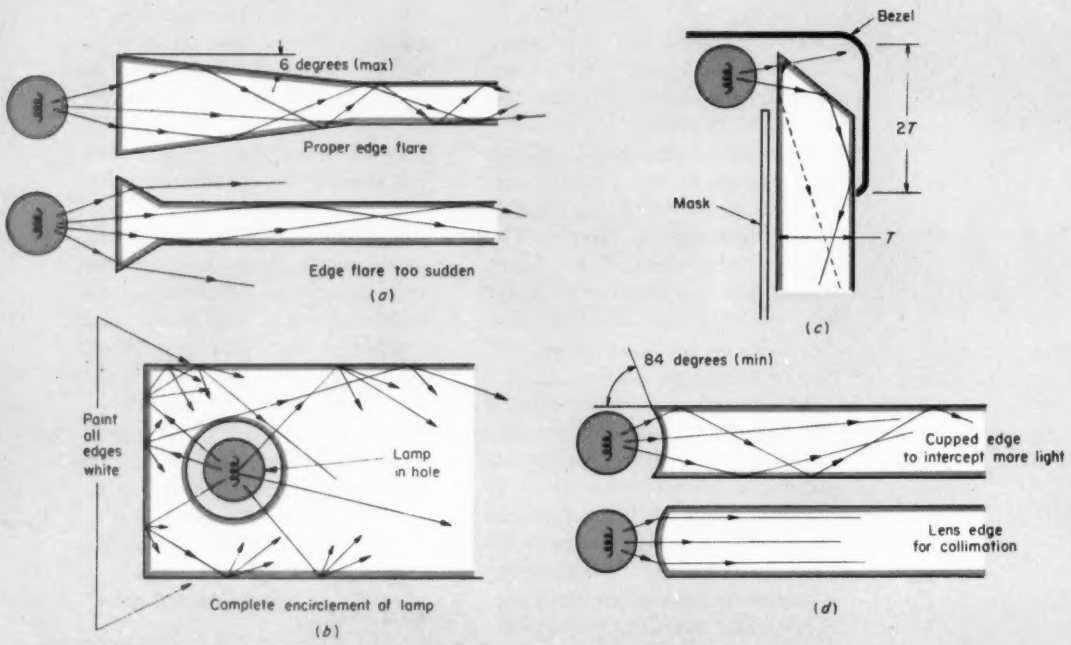


Fig. 1—Light-entry techniques for edge-lighting acrylic parts. Wedge-effect losses are avoided by correctly tapering the part, *a*. Good light distribution and intensity result from complete encirclement of lamp, *b*. A 45-degree facet permits lamp placement when space is limited, *c*. Shape of entry edge of panel influences intensity of transmitted light, *d*.

- **Edge Lighting**
- **Back Lighting**
- **Jewels and Pushbuttons**
- **Wedge Lighting**
- **Prisms and Lenses**

TRANSPARENT plastic parts may be designed to be looked at or looked through; they may be illuminated by natural or artificial light; move or remain stationary; serve their optical functions in bright, dim, or dark environments; or impress the viewer. They may show their planned illumination from a single viewing angle, or from any angle in a wide zone.

Four lighting techniques are common: 1. Edge lighting, which is generally best in low ambient light or dark environments. 2. Back lighting, which is effective under nearly all light conditions. 3. Flood lighting from the side or from above which is useful with opaque parts like pointers or intricately decorated faces and drums. 4. Light piping, a variation of edge lighting in which light is emitted for illumination or viewing from only a single end or edge.

With flood lighting, back lighting, or general ambient lighting, rays are ample and in many directions of travel toward the part. No special knowledge of optics is necessary to understand the behavior of light from such sources at the part. Not so, however, with edge lighting and light piping. Any ray of light within acrylic plastic which encounters an air interface at the critical angle (an angle of 42.2 degrees off the normal) or greater will not be transmitted. It will be totally reflected back into the material at an equal and opposite angle. Such total reflection is the physical basis for light piping, wedge lighting, halo effects, and for solving light-control problems.

▶ Edge Lighting

Four basic factors which must be considered to make the most effective and efficient use of edge-

Why Acrylic Plastics?

Several materials can be used for transparent parts — for instance, glass, polystyrene, and acrylic plastics. Acrylics such as Plexiglas are popular for several reasons: 1. Transparency and translucency in almost any degree. 2. Ample range in color. 3. Surface texture possibilities ranging from high polish to heavy texture. 4. Easy manufacture by injection molding, extrusion, or fabrication from sheet, rod, block or tubing.

Certain conventional definitions and key facts must be kept in mind when designing with acrylics:

Interface is any surface where the acrylic is touched only by air, generally a polished, dry, uncoated surface.

Angles (incident angle, refracted angle, emerging angle) are always between the ray and the normal to interface at the ray's point of contact.

First surface is the front surface of a part held at normal viewing attitude. Second surface is the back surface.

Light losses are about 8 per cent if a light ray strikes a polished acrylic sheet or slab at right angles—mostly due to scattered reflection from first and second surfaces of the part.

Refractive index of Plexiglas is 1.4890. Glasses range from 1.52 to 1.89; polystyrene, 1.58; air or vacuum is 1.00.

Rays striking an interface will be refracted toward or away from the normal. Ratios of sines of the angles involved are inversely proportional to the ratios of the indices of refraction.

Reflection losses when light strikes an acrylic surface are low to an incident angle of about 60 degrees (10 per cent at 60 degrees). So designs should hold incident angles under 60 degrees.

lighted acrylic designs are light-entry conditions, control of light within the part, shape of the part with respect to the light source, and design of the lettering or decoration lighted.

Light Entry: As much light as possible must be directed into the edge of the part, especially for bright-environment applications. The light source should be as close to the edge as thermal conditions permit. Fluorescent and glow lamps develop so little heat that there is virtually no minimum distance limit. Aircraft-type miniature incandescent lamps should be placed at least 1/16 in. away from the acrylic surface, 15-watt sources at least 3/16 in. away, and larger incandescents proportionately further away. These distances are increased for high ambient-heat conditions.

Reflectors behind these lamps increase light into the edge of the part. Satin-finish metal reflectors or flat-white opaque surfaces are best. They distribute the reflected light well and eliminate or minimize dark spots and filament-focus spots. Complete light-box plenums and computed parabolic surfaces are most efficient. Masking of all light not falling on the entering edge is sometimes needed, however, to stop stray leakage.

Since light rays radiate from the source, the thicker the edge, the more light it will intercept. Light-entrance edges up to three times the thickness of the edge-lighted part are common. It is important to taper down to regular part thickness gradually, however, with no more than a 6-degree taper if excessive wedge-effect losses are to be avoided, Fig. 1*a*.

A useful technique for lighting consoles, clocks, and radios, for example, is to insert the lamp in a hole within the edge-lighted part to capture the complete circle of rays in the part plane. The result is high-intensity lighting and surprisingly good light distribution, Fig. 1*b*. The filament should be located between the planes of the two surfaces of the panel.

Where space for a lamp is limited beyond the periphery of the piece, a 45-degree facet cut along the edge permits lamp location behind the edge rather than beyond it, Fig. 1c. However, bezels and masks, as shown, must be used to block unwanted stray rays. Sometimes white paint or metallizing on the 45-degree facet improves performance by reflecting rays striking the bevel at less than the critical angle for total reflection.

Filter-caps or domes over lamps, filter sheets, and transparent coatings applied to the entering edge

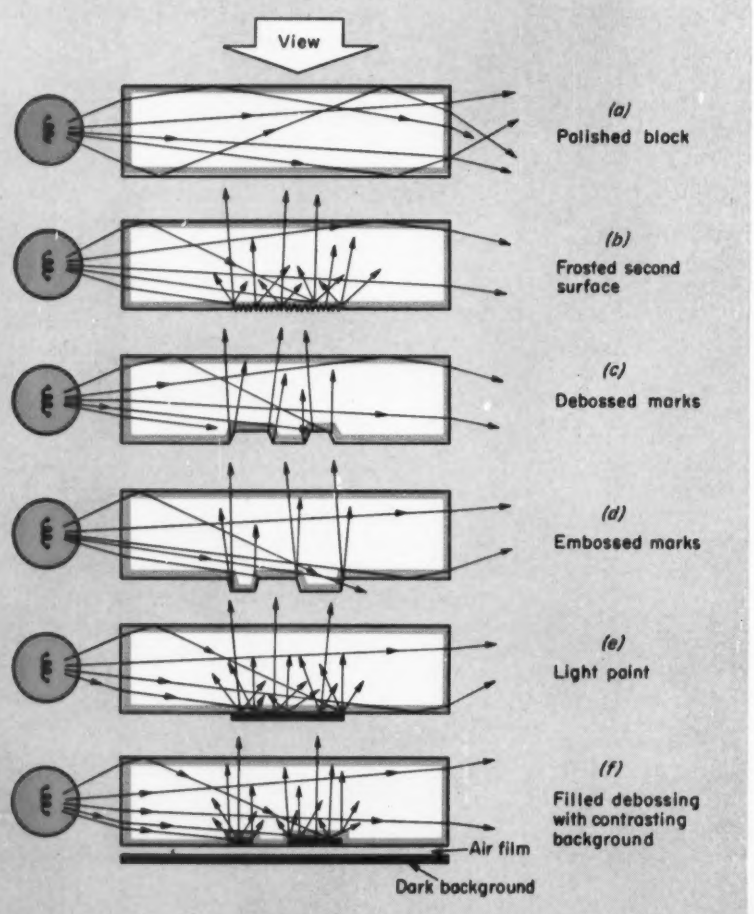


Fig. 2—Influence of condition of the second (or reflecting) surface of an acrylic part on light-ray behavior.

provide color. Variable and moving color is achieved with rotating color discs or with multiple lamps of different hues.

Control of Light Within the Part: To control light which has entered an edge, to eliminate unwanted glare and stray rays, and to cause designs and markings to glow, consideration should be given to localized variations in surface contour, surface finish and texture, coatings of light or dark paint, and metallic deposits. In unfinished rectangular acrylic parts, all light rays will reflect internally between the lateral surfaces to emerge at the edge (or end) opposite from the entering edge (or end). This is true when lateral surfaces of the part are parallel or divergent, are polished for specular reflection, and are in contact with air rather than "wet" with paint or adhesives. Locally altering any of these conditions by one of the four considerations mentioned, causes the rays to be redirected in selected zones in which they are absorbed, scattered, diffused, or reflected as an image. Influence of panel-edge shape on control of light rays is shown in Fig. 1*d*.

Local destruction of the polished reflecting surface by frosting, sand blasting, scratching, or honing will cause light rays to scatter as they strike that zone, Fig. 2*b*. A few rays will pass through the frosted zone as a glow; most will scatter diffusely back across the thickness of the acrylic; and many will emerge from the opposite surface to be viewed as an illuminated marking. Therefore, edge-lighted markings should be located on the back or second surface of the part.

Cutting into this second surface in the form of engraved, incised, or debossed markings will similarly redirect rays striking such markings, Fig. 2*c*. A true reflected image will then pass out of the first surface to be seen in apparently embossed or raised relief. Depending on whether the engraved mark is specular (as molded or polished), frosted, or paint filled, different visual effects will be achieved.

Seldom used, but equally effective and generally easier to produce in molded parts, are raised markings on the second surface, Fig. 2*d*. Such embossed markings are seen through the first surface as apparently debossed or engraved images. Because relatively few of the light rays ricocheting between the first and second surfaces in an edge-lighted piece run parallel to the major surfaces, interception of light by raised or embossed markings on the second surface is nearly equal to the interception by engraved or debossed markings.

Light-colored paint markings applied to a flat, polished second surface by silk screen or hot stamp are effectively illuminated in edge-lighting, Fig. 2*e*. They are seen from the opposite side as markings in relief, although with perhaps less visual appeal than embossed or debossed decoration. Visual effects are similar to frosting but are brighter and more readily seen in daylight environments. Dark paints should not be used with edge-lighted parts since they absorb light and sharply curtail the brilliance of the decoration.

Where dark backgrounds are desired, a second opaque part should be used behind the second surface. It may be almost in contact with the acrylic, but a thin film of air must remain between it and the edge-lighted panel to preserve the air interface for internal reflectivity, Fig. 2*f*.

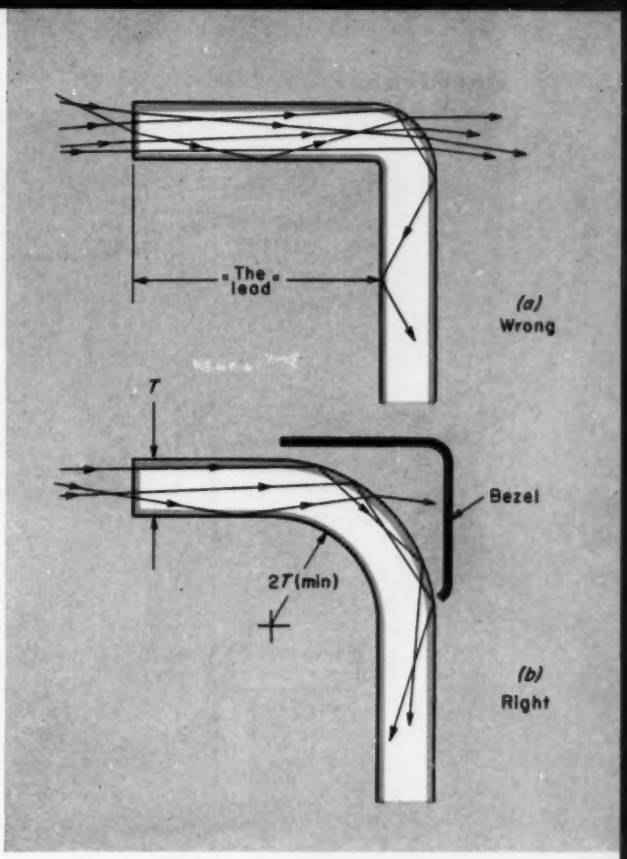


Fig. 3—Design criteria for "piping" light in a curved acrylic piece. Such curved leads are more efficient than sharp bends but require more space.

If a large area of an edge-lighted second surface is to be covered with light paint, a rapid drop-off in brightness can be expected as the distance from the lamp increases. Halftone-dot or grid patterns help in such cases by leaving specular polished areas between the painted areas to act as totally reflecting "stepping stones" for internal light. When a large painted area is to be illuminated, backlighting will do the job better than edge lighting.

Although dark and middle-value markings on the second surface are to be discouraged as not easily edge-illuminated, dark markings may be silhouetted against lighter colored backgrounds. Effective designs have been produced with thin-stroke dark markings on the first surface directly above wide-stroke light markings on the second surface. This creates a three-dimensional effect.

Hot stamping with foils and vacuum metallizing are employed to apply bright metallic silver (chrome or aluminum), gold, or copper sheens to acrylic parts. With such treatment of the second surface, markings depend upon relief for good readability when edge lighted. Metallizing only the letters or markings

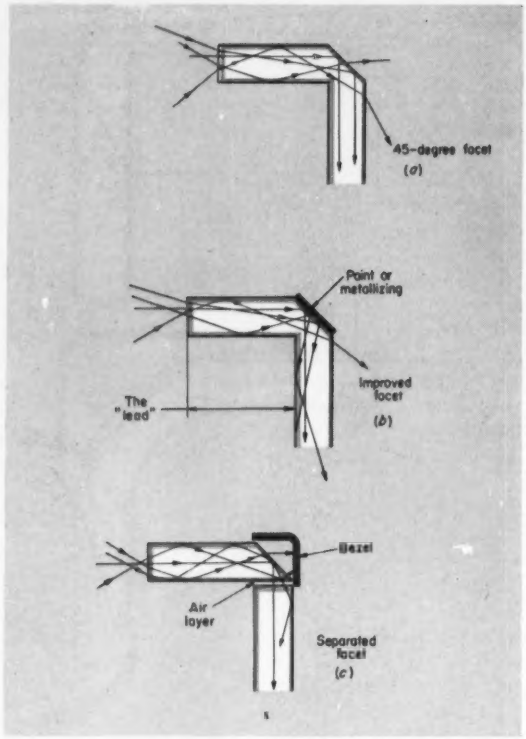


Fig. 4—Techniques for conducting internal light around sharp corners of an acrylic part when space is at a premium.

themselves against a transparent background is effective. The technique is costly with debossed letters. It is easy to obtain in hot-stamped foils on embossed letters (with a flat plate die), but the returns of the letters cannot then be coated. Hot-stamped letters on a flat second surface, if pressed slightly into the materials, give a pleasing edge highlight, but obtaining clean edges on the foil imprints is sometimes a problem.

Surface treatments or texturing of edges (as distinguished from principal surfaces) is a debatable technique. Frosting is not effective as an edge treatment other than when an entering edge is sometimes so treated to reduce bright spots and improve light distribution. Light-colored paint applied to edges diffusely reflects light falling on them to help keep the light within the piece. White paint is desirable for scattering light back through the part as a random flux to make markings on the second surface bright and uniform. It also reduces the number of lamps required to do an edge-lighting job. However, there may be a glow or halo emerging from the parallel principal surfaces immediately adjacent to a painted edge and extending inward a distance approximately equal to the thickness of the part. This band is generally masked by bezel or panel.

Metallizing of edges (and of reflecting facets) reflects light which might otherwise escape from the part, but will not diffuse the flux as uniformly as white paint. Edge metallizing sometimes emphasizes

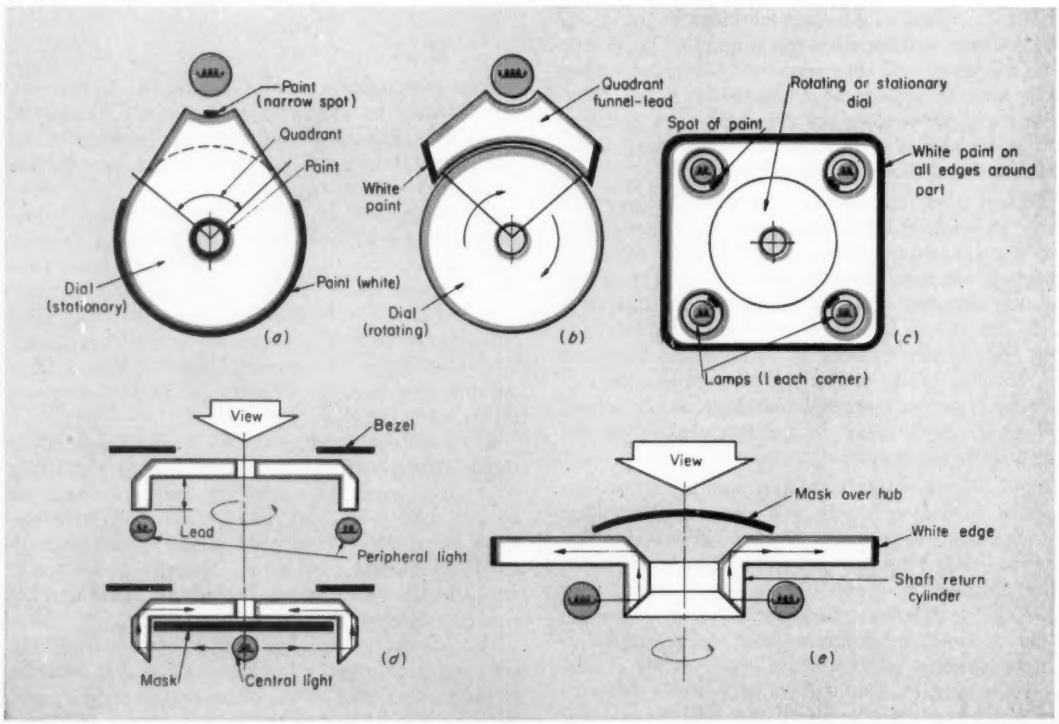
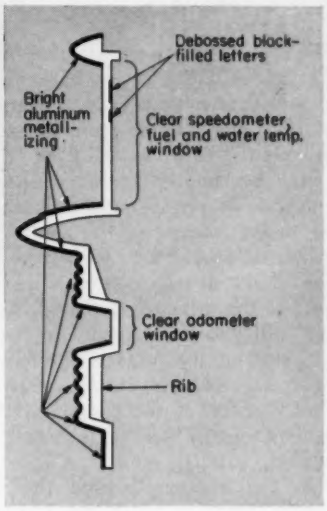


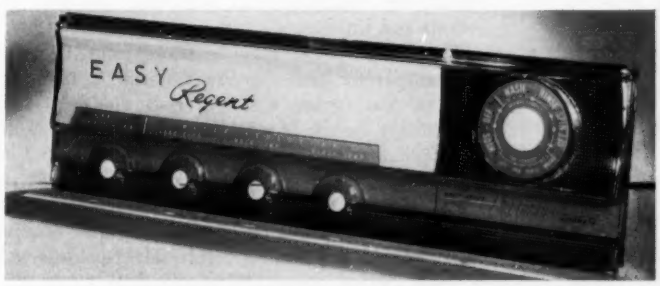
Fig. 5—Methods of lighting variously shaped acrylic parts. These techniques insure maximum brightness and clarity of dials and other indicating faces.

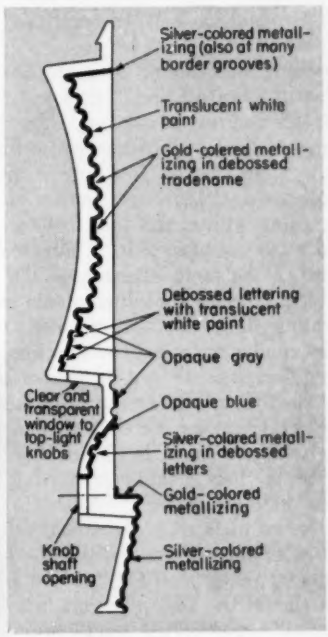


Unitizing Illuminated Acrylic Elements

Cost savings are possible by combining a number of back and edge-lighted acrylic elements into a single piece. A unified backsplash panel on an appliance contains a lighting fixture, linear scales, dials, nameplates, decorative textures, and push buttons. A one-piece acrylic auto instrument panel combines speedometer, fuel gage, oil-pressure gage, water-temperature indicator, ignition signal, transmission selector, clock, radio and heater controls, trademark, and decorative elements. Debossed and black-filled lettering contrasts, third dimensionally, with a side-flooded-light background.

Large empty opaque areas may be a problem in such applications. In preference to opaque paint on the first surface, it is generally better to back up such areas with separate colored or textured background panels. Rear-face opaquing is protected from dirt and wear. Large-unit designs offer opportunities for back-lighting combined with edge-lighting.




Silver-colored metallizing (also at many border grooves)
Translucent white paint
Gold-colored metallizing in debossed tradename
Debossed lettering with translucent white paint
Opaque gray
Clear and transparent window to top-light knobs
Opaque blue
Silver-colored metallizing in debossed letters
Gold-colored metallizing
Knob shaft opening
Silver-colored metallizing

unwanted bright spots and filament images. White paint on edges other than the entering edge can be used selectively to boost brightness and balance light at points furthest from the white source.

Light Piping: To pipe a majority of internal light within a curved acrylic piece, the minimum inside radius must be at least twice the thickness of the part. Otherwise many rays will be lost through the outer surface because they strike it at less than 42 degrees from the normal, Fig. 3. Even with an ample inside radius, those few rays which first strike the inside surface may reflect too steeply across the part and be lost. This does not noticeably reduce available light, but it does result in stray rays that must be masked off in many applications.

When employing a curved lead section into an edge-lighted panel, it is important to pipe light from the top edge or the sides when the panel is in a vertical plane, and from the bottom edge or sides when the panel is in a horizontal plane. This reduces stray rays escaping in the direction of the

viewer's eyes. It is best to complete the curved lead beyond the limits of the visual area if space permits.

Although curved light-leads are more efficient than angled ones, they require more lateral space. When space behind a panel at the edge is not available, light may be conducted around sharp corners up to 90 degrees by employing a polished facet perpendicular to the bisector of the angle. With a right-angle lead, this facet is at 45 degrees, Fig. 4*a*. Since the light from an edge source is seldom collimated (parallel to the principal surfaces), a moderate percentage will escape through the reflecting facet. White paint on the facet is often used to prevent this loss, Fig. 4*b*. Metallizing or hot stamping is even more useful if the design is critical and the expense warranted. Frosting is virtually worthless as a light stop.

When the distance beyond the visual area is stringently limited, and the lead is at right angles to the principal part, the lead and its facet should be separated from the principal part by a thin layer of air, Fig. 4c. This will restrict stray-ray loss to the facet only, and a narrower bezel may be employed.

Matching Part Shape to Light Source: To light circular or elliptical dials, employ a funnel lead of acrylic off from one quadrant of the dial, and paint the edge of the opposite side white through at least half the circle, Fig. 5*a*. If a hole in the center of the dial causes a shadow over some of the lettering, white paint within the hole and around the dial should wash out most of it. A narrow touch of white in front of the lamp filament on the entering edge reduces any bright spot attributable to the filament.

Rotating dials (flat or crowned) may be handled by similar techniques with a break between the rotating part and the lead sections of acrylic, Fig. 5*b*.

An ideal arrangement for brightness is to use a square silhouette for the over-all panel with a lamp through a hole in each corner, Fig. 5c. Paint all edges white. This is similar to having four quadrant leads to a single circle.

On round dials with cylindrical returns (for lateral space economy) use a 45-degree bevel and light the edge of the return, Fig. 5*d*. An additional bevel at the end of the return permits the light source to be located inside of the return cylinder.

Cylinder returns are very useful on rotating dials and do an excellent job. Sometimes the return cylinder is not peripheral, but in the form of a center-shaft sleeve, Fig. 5*e*.

More than one dial may often be illuminated from a single lamp. When fluorescent lamps are used over a row of dials, no lead is necessary because an excess of light is available in a diffused flux from a number of points. This is particularly convenient in appliances where dials are adjacent to a backlighted diffusing panel and the lamp tube extends the width of the appliance.

With rectangular parts, it is best to light from the long edge (preferably the top) with single or multiple lamps. White paint should be used on the opposite edge, especially near the ends. On large parts, use of fluorescent lamps is recommended along the top edge. If vertical space is limited, the 45-degree facet or curved-lead technique should be used. If lighting has to be from one end, the opposite end should always be painted white. However, it is preferable to light from both ends.

Lettering for Edge Lighting: Further variation of embossed and debossed markings can be achieved by the contour of the cameo or intaglio. The relief may have a flat top, round top, or be V-shaped. In general, incised-lettering depth should not exceed 30 per cent of the thickness of the panel or dial on which it occurs. Returns at the sides of embossed or debossed lettering should have ample draft. Sharp corners should be "broken" to minimize molding problems of flow. "Tails" from sharp corners can be particularly objectionable in edge-lighted parts.

▶ Back Lighting

Back lighting is the generally preferred method of illuminating panels and operating instructions. It is also the best method of illuminating elements which must appear brightly lighted when observed under high ambient light conditions.

Fluorescent lamps offer more useful light with less heat for back lighting purposes than filament lamps. With fluorescents, spacing is less critical, shadows are minimized, no filament images need be considered, and the light source is distributed along a line rather than at a single point. A rule of thumb for tube spacing is: Equal distances between tubes and from tubes to back-lighted panel. When tube ends must butt for long runs, they should be overlapped to eliminate shadows from sockets and fittings.

The image panel may be translucent, or it may be transparent with translucent and/or opaque decorative coatings on either or both surfaces. When translucent acrylic is used, decorative coatings must be applied to the front surface for crisp outlines. This means, however, less durability against handling and cleaning. All components and surfaces inside the light box behind the transilluminated panel should be of satin-finish, silver-colored metal or, even better, coated in matte white paint.

Where space and dimensions indicate, light may be flooded from the top or sides onto an opaque canted reflecting panel behind the translucent panel. Such reflecting surfaces may be either flat (set at an appropriate angle) or parabolic with the light source at the focus. Reflected back lighting does not produce as much brightness as direct back lighting. Reflected back lighting is used mainly when lamp access or space is a problem.

Dual-Panel Lighting: This is a combination of edge lighting and back lighting used when space behind the panel is severely limited and when the main-panel area is predominately dark or opaque with lines of brightly illuminated copy. The back-

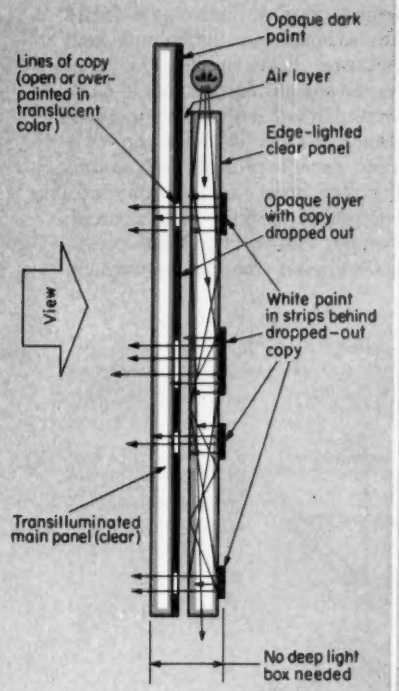

Opaque dark paint
Lines of copy (open or over-painted in translucent color)
Air layer
Edge-lighted clear panel
Opaque layer with copy dropped out
View
White paint in strips behind dropped-out copy
Transilluminated main panel (clear)
No deep light box needed

Fig. 6 — Dual-panel back lighting.

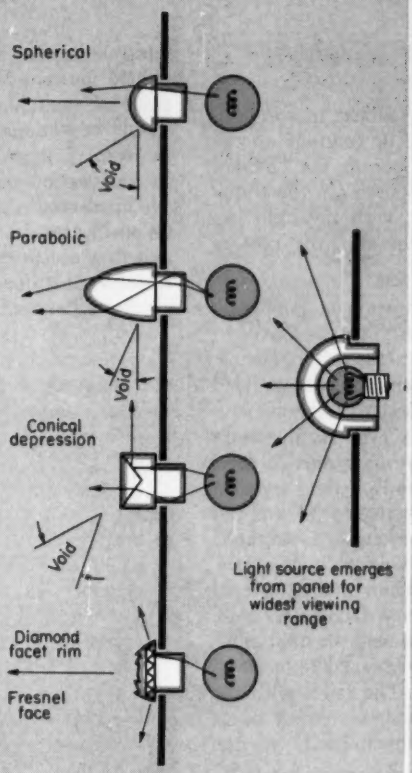


Fig. 7—Indicator jewels, left, and illuminated cup, right. Shape of the jewel is determined by the position of the viewer. The illuminated cup gives the widest viewing range because the light source itself penetrates the panel.

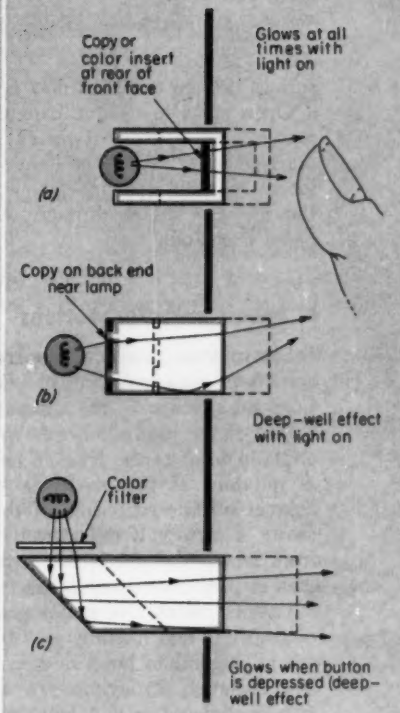

Copy or color insert at rear of front face
Glows at all times with light on
(a)
Copy on back end near lamp
(b)
Deep-well effect with light on
Color filter
(c)
Glows when button is depressed (deep-well effect

Fig. 8—Variations of lighted pushbuttons.

lighted panel is rendered opaque on the second surface by spraying, screening, or masking, with copy dropped out and overpainted in a light translucent coating, Fig. 6.

In the limited space behind this panel, a second panel is strongly edge lighted. It must be separated from the back-lighted panel by a thin layer of air. On the second surface of the edge-lighted panel (directly behind the copy elements on the back-lighted panel), areas of white paint are applied. These catch and diffuse the light piped within the edge-lighted panel at the precise areas desired.

Painted zones of the edge-lighted panel should not exceed 20 to 30 per cent of total panel area. Long strips of copy parallel to the entering edge (light source) are acceptable, but copy should not be more than $\frac{3}{8}$ to $\frac{3}{4}$ in. high.

Copy Tips for Transillumination: Transparent copy on a back-lighted panel must be designed to prevent direct view of lamps and light-box structures and to eliminate glare when viewing. Translucency is generally preferred to transparency. An exception is planned transparency to disclose animated effects or special optical-texture areas.

Translucency in copy can be achieved in two ways. Appliques of translucent acrylic pieces of different hues can be used, but most back-lighted panels are made from a single transparent sheet or molded form. The translucency is applied as paint on the rear surface.

The range of translucent coatings available is almost infinite. With sheet parts, application of the coating is simple. With injection-molded parts, careful consideration should be given to the feasibility of applying the coating before the part design is frozen. It is not always easy to coat intricate contours, especially those in deep relief.

To emphasize the third-dimensional quality of lettering on the back surface of a transilluminated panel, a front-surface repeat of the marking (as a superimposed centerline or outline) in contrasting color is sometimes effective. Portions of a single panel illuminated from behind may be isolated with "egg-crate" dividers or individual light boxes.

Back lighting with fluorescents, neons, cold cathodes, or incandescents is vastly superior to edge-lighting for such isolated-copy work. Back-lighted translucent panels are often used behind cut-outs in opaque panels. Opaque color screened onto the front

surface is often used, but may be subject to abrasion.

Open areas in opaque panels, or coatings on the rear side of translucent panels, permit the "hidden message trick." With the light source off, the translucent material appears opaque; with the light on, the message shines through wherever the opaque panel is cut out.

Jewels and Pushbuttons

For indicator-jewels, transparent injection-molded acrylic is principally used. Designs should consider the position of the viewer's eye. As shown in Fig. 7, if the viewer's eye is within a narrow solid angle in front of the jewel, a hemispherical segment is suitable. If the viewer is between 30 and 60 degrees off the centerline of the jewel, a parabolic shape is useful. If the viewer is close to the plane from which the jewel emerges, and to one side of it, a conical depression in the front face works well.

Fresnel patterns of radial grooving, combinations of polishing and frosting, and diamond-like faceting, are all helpful in jewel design. The jewel with the best radiation throughout the widest viewing range is a cup placed over a lamp which, itself, emerges from the panel.

High contrast ratios are more important than candlepower values in indicator jewels. Bright colors at the warm end of the spectrum are more readily seen under poor contrast conditions. Subdued colors at the cool end of the spectrum may be desirable in high contrast conditions such as a dark cockpit.

Illuminated Pushbuttons: The most satisfactory multiple-button designs provide for individually lighted buttons with a lamp directly behind each point of manual pressure. For long life, the lamp should be stationary, and the pushbutton should move in front of it or around it. Ventilation to prevent heat distortion of thermoplastics is important.

Cup-shaped designs permit printed designations to be located on the rear surface of the front face, and they accept changeable color filter inserts and/or translucent diffuser plugs, Fig. 8*a*. Cups also permit shorter distances between lamp and point of pressure.

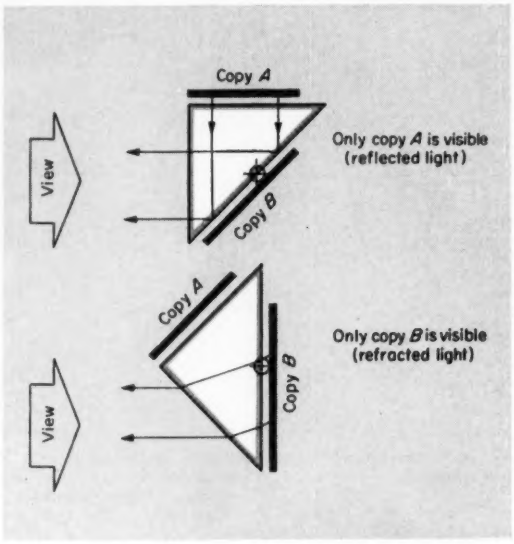


Fig. 9—Two-image flip prism, 45-degree rotation.

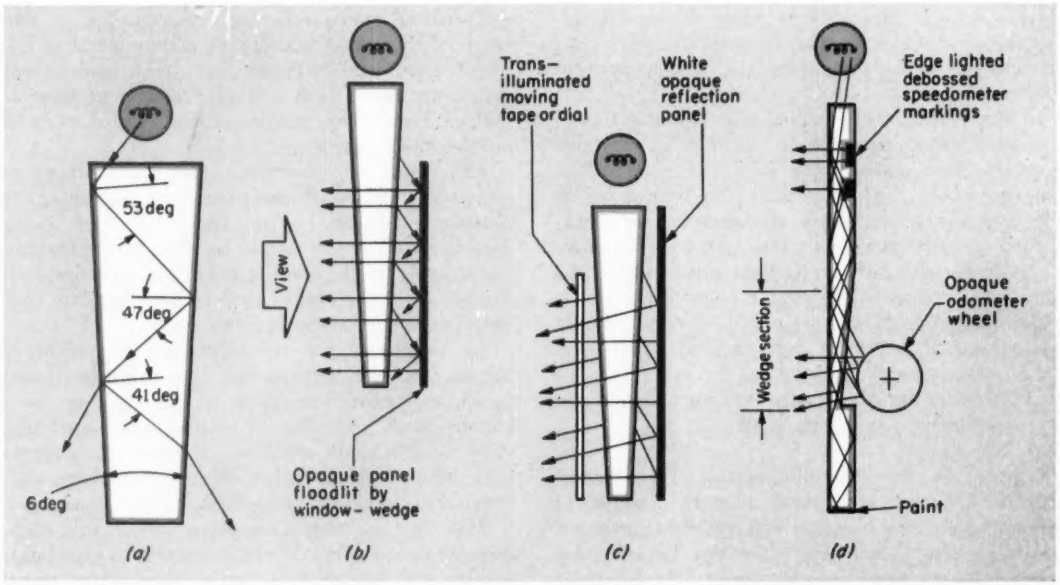


Fig. 10—Wedge lighting adapted to various applications. This type of lighting can be used effectively to illuminate opaque surfaces without glare or reflection.

Solid back-lighted buttons require deep assemblies for lamp clearance and exhibit "deep well" effects where lettering is on the rear surface near the lamp, Fig. 8*b*. To avoid this, symbols should be on the front of the button but, at this location, they present problems of wear, dirt infiltration, and tactile roughness. Solid push-buttons have appeared with thin diffuser discs cemented to the front of a clear button. The construction is generally more costly than need be, and care is required to avoid contamination, color effects from the cement, and solvent attack.

Ranks of many buttons in a single line may be illuminated by sidelighting from a single lamp. Fig. 8c. A 45-degree facet for total reflection is satisfactory, but the "deep well" effect limits the glow to almost dead-ahead viewing.

Another pushbutton illumination technique is to side-light a faintly translucent part without optical-control facets at all. Side-lit translucent plastics give the appearance of a fog. Entering light is widely scattered by the pigment particles, and some of it glows out the front of the button. Colors and tints are essential to good readability of pushbuttons in high ambient light conditions.

Buttons may also be lighted with the flux emerging from an edge-lighted panel which they pierce by arranging for a rear-facet to fall within the plane of the edge-lighted panel when the button is depressed. Thus, the button glows in the operating position only.

Two-image readouts, easily designed from prisms, are pivoted so that different opaque image surfaces may be viewed from the same position depending on the orientation of the prism, Fig. 9. One image is totally reflected from the 45-degree facet; the other image is transmitted through this same face and one adjacent face by prismatic refraction.

▸ Wedge Lighting

Light entering the thickest edge of an acrylic wedge exhibits an interesting behavior which is used to illuminate opaque dials, multiple-pointer systems, digital read-out windows and counter drums without glare or reflection and in tight quarters. Such light is reflected back and forth between the principal surfaces as in normal edge lighting. However, at each reflection, the angle of incidence becomes progressively closer to normal until it is less than 42.2 degrees and the light pierces the air interface to escape from the part at both faces of the wedge, Fig 10*a*.

The distance from the thick entering edge to where light begins to escape through the principal surfaces is a function of wedge angle, thickness of the part, and the extremes of angularity with which light enters. The best way for a designer to anticipate the escape line is to make a graphical study. For most wedge-lighted parts, the convergence angle should be generally 2 to 5 degrees. Greater angularity may be used in prismatic lighting grids or in injection-molded applications.

Wedge lighting offers the designer an opportunity to flood-light an opaque surface from the front by means of a thin transparent screen, Fig. 10*b*. No more than a fraction of an inch of frontal distance is required. In addition, such front lighting is superior to conventional flood lighting from the standpoint of reflected glare since the flux is fairly uniform. The wedge principle is especially useful for low levels of uniform lighting in a low ambient-light environment. Also, the wedge panel combines the attributes of protective window and light source.

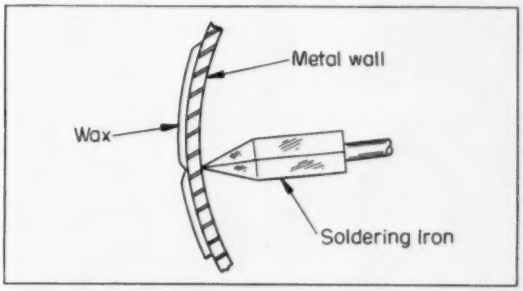
Wedge lighting has also been applied to the back lighting of moving translucent tapes and dials by putting a highly reflecting white opaque surface behind the wedge and moving the translucent tape or dial in front of it, Fig. 10c. Data tapes may be thus illuminated without deep light boxes behind them.

One variation incorporates a wedge area in an otherwise parallel-sided and edge-lighted panel, Fig. 10*d*. An illuminating flux emanates from the wedge section to light opaque elements in its vicinity, but no flux emerges from the parallel-sided sections except at edge-lighted lettering or decoration engraved on the second surface.

Tips and Techniques

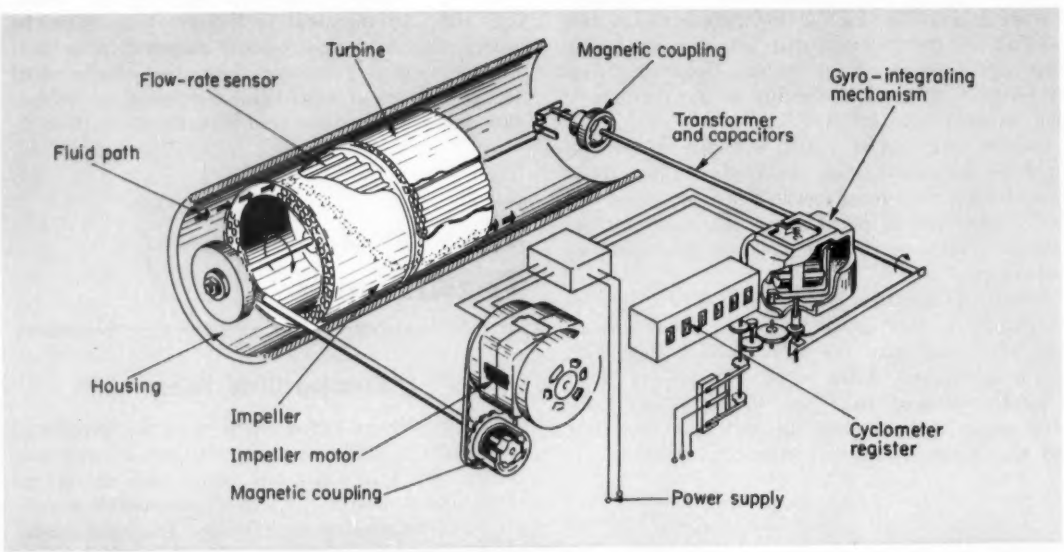
Locating Blind Points

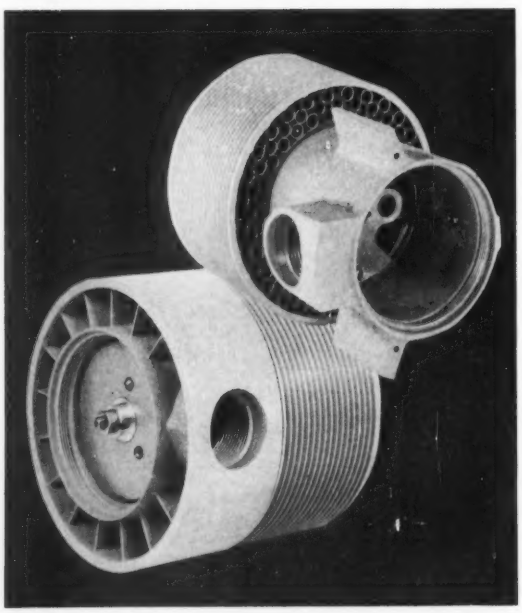
Occasionally in experimental work the location of two points opposite each other through a metal wall is required. Frequently one point, such as on the inner side of a tank, is relatively inaccessible to conventional measuring techniques. To avoid undesired perforation of the metal, a smooth layer of wax or other harmless material of low melting point is applied to the region. From the easily reached side a sharpened soldering iron is held on the desired point. Heat from the iron, conducted through the wall, first melts the wax, on the inner side, at a point directly opposite the iron. This technique



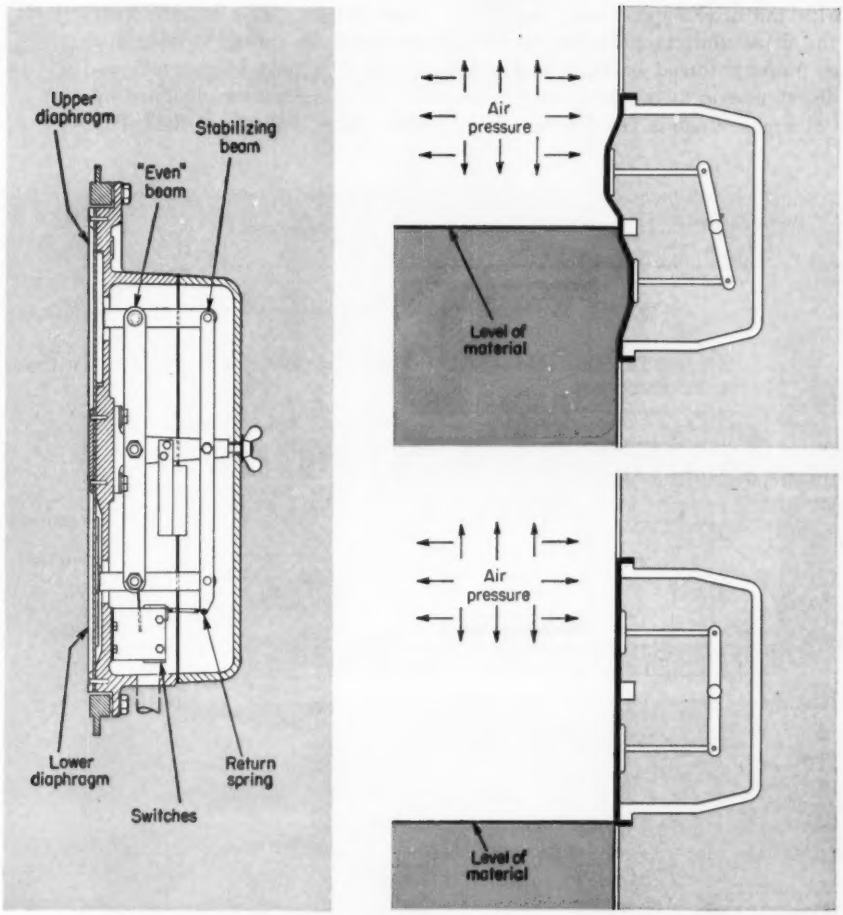
can be checked for accuracy by using small measurable samples of the metal and wax.—Andrew King, *Mechanical Engineering Laboratory, Alabama Polytechnic Institute, Auburn, Ala.*

scanning the field for *ideas*



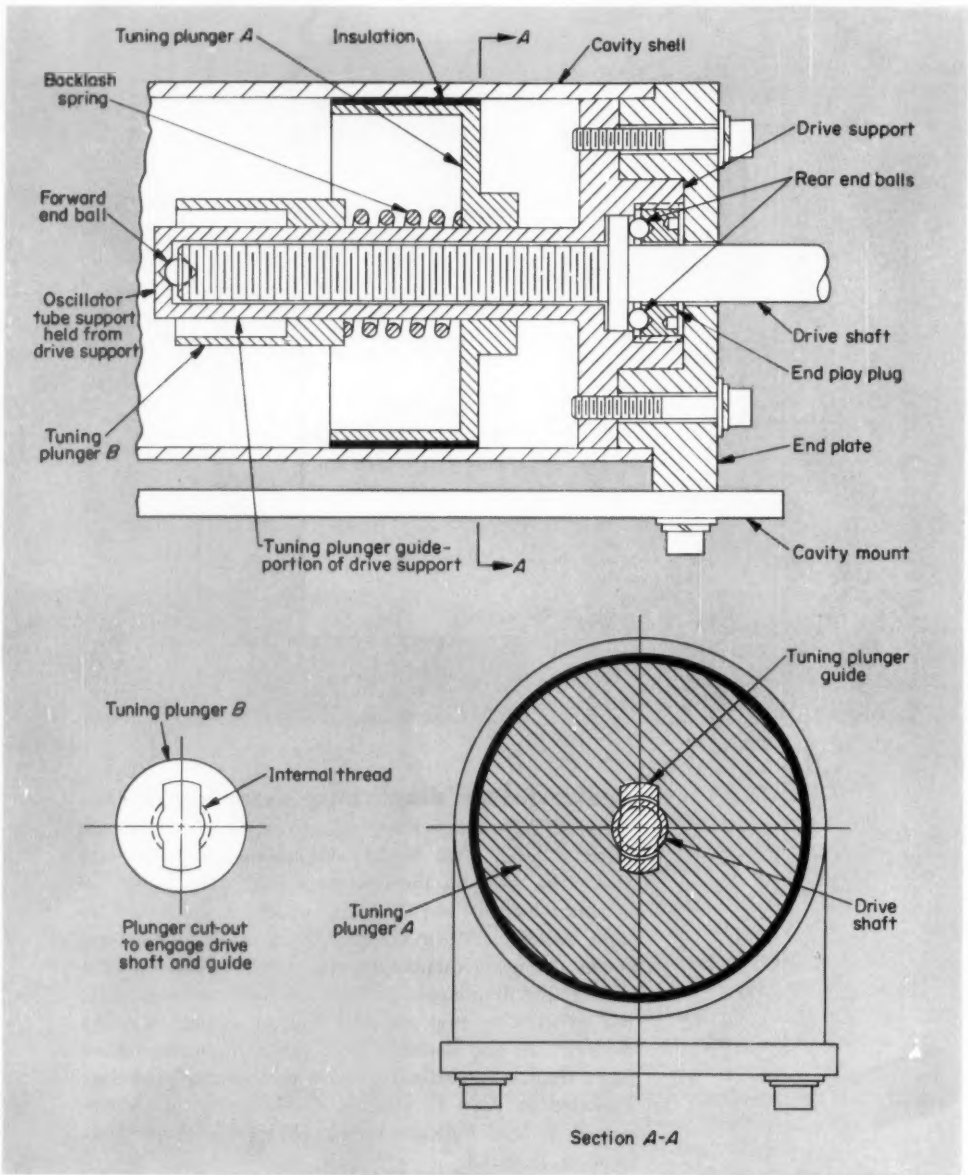


Twisted fluid path permits mass rate of flow to be determined directly. A flow-rate sensor, located in the fluid stream, consists of two cylindrical elements, an impeller and a turbine. Both elements contain channels through which the fluid flows. The impeller, driven at a constant speed, imparts a "twist" (or angular velocity) to the fluid as it flows through the unit. The amount of angular momentum added to the fluid is proportional to the mass rate of flow. As the fluid flows from the impeller into the fixed turbine, a measurable torque is imposed on the turbine. This torque is proportional to the angular momentum and, hence, to the mass flow rate. Impeller-turbine principle employed in a mass flowmeter developed by Instrument Div., General Electric Co., West Lynn, Mass.



Teeter-totter diaphragm assembly senses pressure differences along container wall to indicate material level. Two flexible diaphragms, mounted one above the other in the container wall, are coupled by a spring-loaded "even" beam which is connected to limit switches. As material rises in the container and covers the lower diaphragm, the weight of the material deflects the diaphragm, rocking the beam and operating the switches to stop material flow or actuate warning devices. As the material level falls, the spring-loaded beam resumes its original position and closes the switches. Reported by Alan K. Jackson, diaphragm principle employed in level indicator developed by Blaw-Knox Ltd., London, England.

Twin-plunger screw drive extends range and accuracy of microwave measurements. In an echo box design for amplifying frequencies, two plungers are set for individual wave frequencies by starting each at specific angular positions with respect to the drive screw thread. The screw is prevented from moving linearly by balls at the forward and rear ends. When the plunger position is set, the end-play plug is peened, permitting the drive screw to rotate. The drive support, held firmly to the end plate, supports the drive shaft and allows the threaded portion of the shaft to move the plungers. The tubular portion of the drive support is cut away on both sides, exposing the screw threads. Tuning plungers *A* and *B* mate with the drive support and engage the screw thread. The drive support holds the drive shaft in place and guides the plunger. A spring between the plungers prevents thread backlash and a ground thread is used to maintain accurate linear motion as the drive shaft is rotated. Drive mechanism designed by Arthur Shafran, Western Development Lab., Philco Corp., Palo Alto, Calif.



Is a manufacturer legally liable for

- **Directions in an instruction manual**
- **Advice on product operation**
- **Field services by engineers**

Here are the pitfalls faced by a "Good Samaritan" manufacturer in

Volunteering Technical Services

ALBERT WOODRUFF GRAY
Forest Hills, N. Y.

The law imposes an obligation upon everyone who attempts to do anything, even gratuitiously for another, to exercise care and skill in what he has undertaken.

Even a stranger or a volunteer is liable for an injury negligently inflected on the person or property of another. The Good Samaritan incurs a responsibility avoided by those who pass by on the other side.

—Illinois Appellate Court

A MANUFACTURER of farm equipment delivered a tractor to a farmer in Minnesota. With this tractor the manufacturer supplied an instruction book which stated, "The recommended engine speed is 1400 r.p.m. which produces a belt pulley speed of 933. If no speed indicator is available, you may set the gears in low, run the tractor over the ground and count the revolutions of one of the rear wheels. The wheel will turn 16 times per minute with an engine speed of slightly less than 1400." Also under the heading "Specifications of the Engine" was "RPM. . . . Maximum 1400."

In hauling a loaded trailer, the tractor was being driven by the farmer down a 20 per cent grade on a gravel road in low gear, using the engine to retard the speed. Accelerated by gravity, the tractor increased speed to 7 mph with the belt pulley revolving at approximately 2500 rpm. At this speed, the pulley burst from centrifugal force and injured the operator.

Although the book of instructions specified the maximum speed, it gave no warning of this danger. Subsequently, the manufacturer was found liable by the Minnesota Supreme Court:

"If the manufacturer undertakes by printed instructions to advise of the proper use to be made of a chattel, he assumes the responsibility of giving accurate and adequate instructions with respect to the dangers inherent in its use in some other manner."[1]

A similar case had occurred a few years earlier. A manufacturer of gas heating equipment had omitted from its operating instructions certain directions for determining the open and closed positions of the main hand valve. Consequently, incorrect manipulation of the burner introduced free gas into the combustion chamber, which exploded and killed

[1]References are listed at end of article.

an operator.

Here, a judgment against the manufacturer stated that failure to make printed instructions adequate and accurate constituted negligence.[2]

IN Kansas, gas heating equipment had been installed under a contract which read, in part, "The services of our engineers and service men are available to you at any time for consultation and supervision of the above work."

Each time this appliance failed to function, the owner sought assistance from the company which made efforts at adjustment. One cold day the furnace failed to operate. The owner went to the cellar, lighted a match at the door of the furnace, and was severely injured in the explosion that followed.

In its defense to a suit for negligence, the company contended that it was not obliged to give instructions. Consequently, no liability could be imposed for not doing an act it was not obliged to do.

Sustaining a decision awarding damages to the victim, the Kansas appellate court said, "It is urged by this company that it was not required to give instructions. Assuming that to be true, it did give some instructions and having done so it was its duty to go further and give instructions at least complete enough to cover the various phases of operation."[3]

AN authority in these cases is the decision of a case in New York state involving a kerosene-powered machine which had been purchased by a farmer. In making this sale, the manufacturer had agreed to teach an employee of the purchaser in the operation of the machine.

The promise was kept, but the instructor failed to caution the employee against touching an attachment that would immediately set the machine in motion. Later, the employee hit the device, and was injured.

In a liability suit, the court ruled that the author of this promise for instructions, when having undertaken to perform, was liable for the consequences of a failure to do so. In defense, the manufacturer urged that there had been no agreement made with the injured man, but only with his employer. The manufacturer contended further that there can be no negligence without a duty resting on the accused.

In reply, the court said, "There was no contractual relation existing between these parties, therefore the liability of the manufacturer for the injuries received by the employee, if any exists, results from the failure to observe the obligation which the law imposes upon a party engaged in the prosecution of any work, of performing the same in such a manner as not to endanger the lives or persons of other parties."[4]

AS the previous cases have implied, the courts are not as concerned about failure to perform a gratuitous service as they are with misperformance of a voluntary act. The scope of the general rule followed by the courts in such cases is perhaps best summed up by a decision of a New York case over a century and a half ago: "One who undertakes to do an act for another without reward is not answerable for omitting to do the act and is only responsible when he attempts to do it and does it amiss. In other words, he is responsible for a wrongdoing but not for a non-doing."[5]

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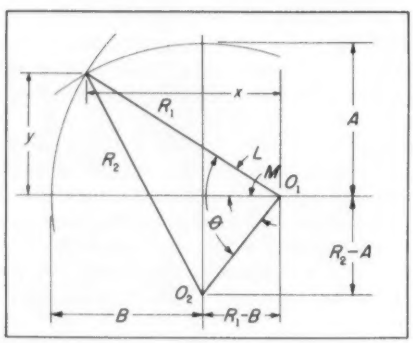
1. Lovejoy v. Minneapolis-Moline Power Implement Co., 79 *N.W.2d* 688, Minnesota, December 7, 1956
2. Hartman v. National Heater Co., 60 *N.W.2d* 804, Minnesota, October 30, 1953
3. House v. Wichita Gas Co., 20 Pac. 2d 477, Kansas, April 8, 1933
4. Miller v. International Harvester Co., 184 N.Y.S. 91, New York, June 6, 1920
5. Thorne v. Deas, 4 Johns. (N.Y.) 84, New York, February, 1809

Tips and Techniques

Locating Arc Intersections



Cartesian co-ordinates of a point at the intersection of two circular arcs are often required in layout problems. The designer will find the following formulas useful.

$$\frac{(R_1)^2 + [(R_2 - A)^2 + (R_1 - B)^2] - (R_2)^2}{2R_1\sqrt{(R_2 - A)^2 + (R_1 - B)^2}} = \cos\theta$$

$$\frac{(R_1 - B)}{\sqrt{(R_2 - A)^2 + (R_1 - B)^2}} = \cos M$$

$$x = R_1 \sin L$$

$$y = R_1 \cos L$$

—J. DIANI, *Marlboro, Mass.*

Thermal Stresses in Design

Part 14 — Strain-Gage Measurements

- *Techniques*
- *Materials*

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EXPERIMENTAL strain measurements are a useful tool in design studies which must account for thermal stresses. The information they provide can be used to advantage in a number of ways:

1. Verification of theoretical analysis. This verification is particularly desirable if approximations of unknown validity have been introduced into the analysis. For example, if the hull of a ship or the nozzle guide-vanes of a gas turbine are considered simple beams in a thermal-stress analysis, many questions arise that can best be resolved by experimental evaluation. Usually the simplest experiment incorporating the essential features to be evaluated is conducted. If the theory is verified for the simple case, more complicated cases can be verified by extending the analysis without further tests.

2. Development of the basis for analysis in complex cases where simplifying assumptions are not self evident. Thus, for example, the diffusion of heat through the complex structure of aircraft in flight introduces complicated thermal-stress systems. Experimental evaluation of several cases may lead to simplifying assumptions whereby the structure may be reduced to substructures capable of individual analysis. For such purposes, also, the experimental set-up needs only those essential features that require investigation. Hence, not all actual conditions need be simulated. High temperatures actually encountered may, for example, be replaced by a similar temperature distribution in a lower temperature range. Then, measuring techniques, such as photoelasticity, which would not be applicable if the actual temperatures were simulated, can be used. Once the principles are established, they may be cautiously applied to a broadened range of conditions where measurement would be difficult.

3. Actual determination of thermal stresses in machine parts under conditions encountered in practice. This application is difficult since the instrumentation must be capable of withstanding severe environmental conditions.

4. Miscellaneous indirect applications. Here the principal objective may not be a stress determina-

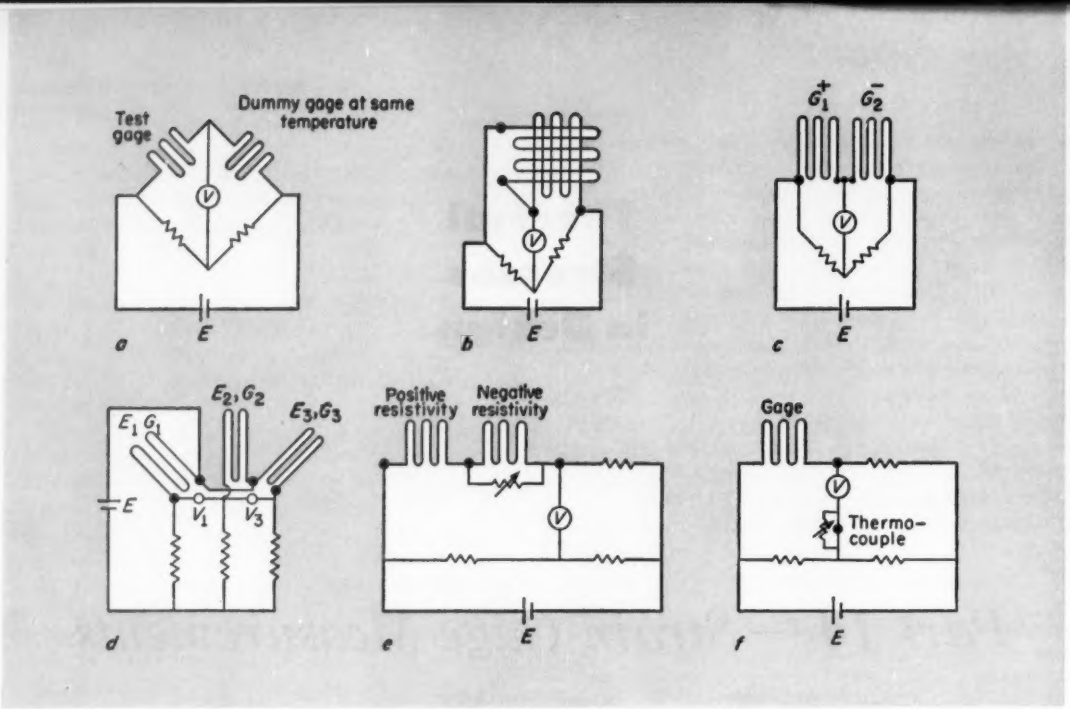


Fig. 81—Circuits for temperature compensation in thermal measurements by resistance strain gages; *a*, dummy gage in stress-free element, *b*, cross-wire gage for one-dimensional stress, *c*, two gages on opposite sides of test piece, *d*, rectangular rosette, *e*, combination of positive and negative resistance elements, *f*, compensation by thermocouple bucking voltage.

tion but, instead, may involve stress measurement as a means toward achieving the final goal. For example, the thermal stress at a point in a free flat plate with symmetrical one-dimensional temperature distribution depends only on the difference between the temperature at that point and the average temperature. Thus, the average temperature can be determined by simultaneous measurement of stress and temperature at a single point, and can then be used in heat-flow calculations. While such an application involves the direct measurement of thermal stress, the more common application involves measurement of residual stress after the body has been returned to uniform temperature. Thus, residual-stress measurements are used to check the relative validity of deformation and incremental theories of plasticity. Similar determinations on quenched cylinders can yield valuable information on the thermodynamics and mechanics of quenching.

Design Approach: Experimental determinations of thermal stresses make use of the same tools as used for mechanically induced stresses. In all cases, the quantities measured are strains, and stresses are indirectly determined from stress-strain relations. All techniques of experimental stress analysis are thus available for thermal-stress measurement, although the problem is greatly complicated by the inherent presence of a range in temperatures. This is particularly true if the temperatures in some locations are high.

Wire and foil resistance strain gages, photoelasticity, stresscoat, mechanical and optical extensometers, and X-ray diffraction have all been used in specialized applications of thermal stress analysis. The most versatile tool is the strain gage. However, recent developments in photoelasticity have increased its scope for this application.

In this article, attention will be focused on the requirements of strain-gage measurement systems. Each of the available techniques, their potential and limitations, and the type of results obtained are examined.

Measurement Requirements

The strain gage is the most versatile tool for measuring thermal stresses. As in the measurement of mechanically induced stress, the gage indicates strain induced by the stress. The strain manifests itself as a proportional change of resistance of the gage. However, the part tested frequently undergoes temperature changes and, sometimes, is subjected to high temperature during the measurement program. Hence, many considerations enter into the selection of materials and circuitry for thermal-stress measurement that are of lesser importance in mechanical-strain measurement:

1. Compensation for temperature of gage resistance element. The gage changes both natural length and resistivity as a result of temperature change. The

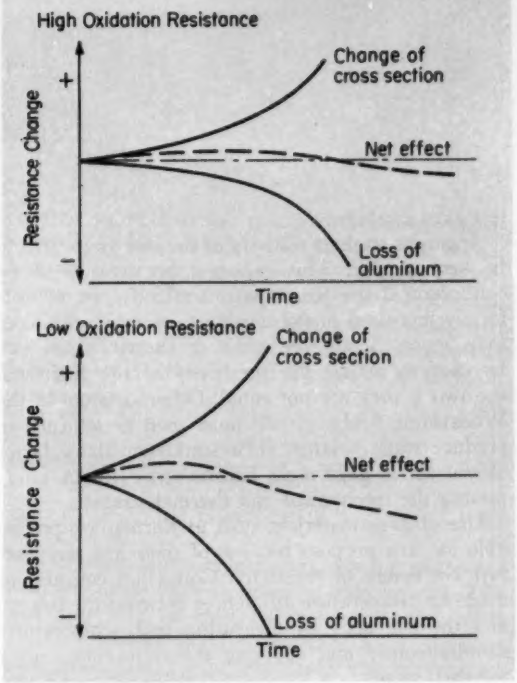


Fig. 82—Apparent strain versus temperature for several lots of Advance wire mounted on a stress-free steel specimen.

coefficient of expansion of the gage wire is, in general, not equal to that of the test material. But, the length of the wire is forced to conform to the expansion of the test surface. Hence, even if the gage is mounted on a material which is free to expand, the gage indicates a change in resistance as the temperature of the system is increased. This change is due partly to the change in resistivity and partly to the net expansion which takes place during the temperature application.

If a strain, ε_t, exists in the material due to thermal stress, the gage will show an additional change of resistance due to this strain. Thus, if R is the resistance of the gage and ΔR the change in resistance for a change in temperature ΔT,

$$\frac{\Delta R}{R} = k\varepsilon_t + \beta_g(\Delta T) + k(\alpha_t - \alpha_g)(\Delta T) \qquad (105)$$

where k = gage factor of the material, unit change of resistance per unit strain; β_g = temperature coefficient of resistivity of the gage material, unit change of resistance per unit change in temperature; and α_g, α_t = temperature coefficient of expansion of the gage and the test specimen respectively; unit change in length per unit change in temperature.

Since the factor of interest is ε_t, methods must be provided to separate it from the incidental changes in resistance which are not related to the thermal stress as developed.

2. Evaluation and control of resistance changes due to time-dependent chemical and metallurgical factors, and creep in the bonding material, especially when high service temperatures and long test times are simulated. Small dimensional and metallurgical changes of the gage material can cause large changes in resistance. When test times are appreciable, these changes must be minimized and accounted for together with apparent changes in strain due to creep of the bond.

3. Elimination of thermoelectric and lead-wire resistance effects at junctions between dissimilar metals subjected to temperature changes. Any junction between a gage wire and a wire of a dissimilar metal, regardless of whether it is a component of the strain-measuring bridge or a lead wire, constitutes a thermocouple which generates a changing voltage as the temperature is changed. This voltage must not appear indistinguishably from the desired voltage representing the thermal strain.

Temperature Compensation

When the temperature varies slowly, and the temperature gradients are not severe, the simplest approach is to measure the temperature simultaneously with the indicated strain. The temperature effect can then be compensated by calibrating a specimen of the test material free to expand when heated, or by computation from the gage factor and the expansion coefficients of the test material and the gage material, Equation 105. These readings should be stable and reproducibly a function of temperature only.

Among the gage materials suitable for this approach are the copper nickel (Advance), nickel chro-

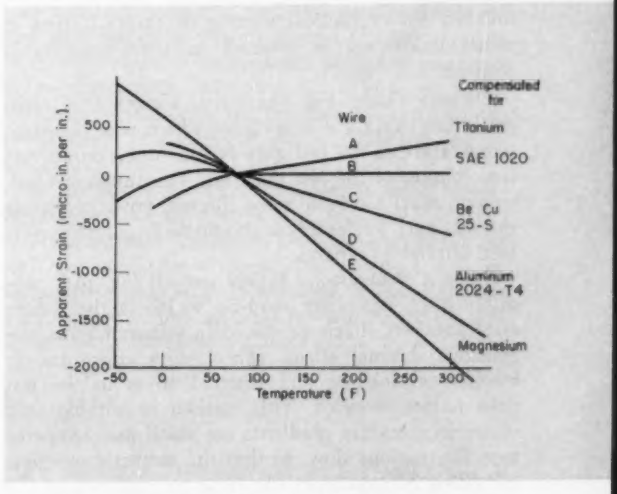


Fig. 83—Compensating effects of oxidation on resistance changes in aluminum-bearing alloys.

mium (Nichrome V), and nickel-chromium-aluminum (Karma) alloys. Another class of materials that is under development as strain-sensitive elements is the iron-chromium-aluminum series.[14] Among these, alloy D has received the greatest attention due to superior oxidation resistance.

For temperatures below 550 F, the copper-nickel alloys are most commonly used because of superior cost, stability, gage factor, and resistivity characteristics. Above 550 F, this material suffers from intergranular corrosion. Hence, it is not as suitable as other materials for static-strain measurement. Karma is competitive with Advance below 550 F, and greatly superior in the temperature range between 550 and 800 F. Above 800 F, Karma undergoes a metallurgical transformation, and becomes unsuitable for static-strain measurements.

Nichrome V is metallurgically stable for static-strain measurements up to 1000 F. It has been used as high as 1200 F, but its high-temperature coefficient of resistance makes the results very sensitive to small inaccuracies in temperature determination.

Armour alloy D has been tested for static-strain measurements to 1600 F.[14] Although it does not undergo phase changes, it has a large apparent temperature coefficient of resistivity when mounted as a strain gage on most engineering materials.

Suitability of the post-measurement compensation technique depends on temperature range involved, rapidity of test temperature changes, duration of test, and test material.

Combinations with Supplementary Elements: An alternate approach to the problem of temperature compensation is to combine the strain indication of the gage with that of another element subjected to the same temperature and different strain. The strain indication due to the gage itself is canceled by the supplementary element, while the required strain induced by mechanical loading or thermal stress is either unaffected or affected in some predictable manner.

DUMMY GAGE: Fig. 81*a* shows a method of compensation using a dummy gage which is at the same temperature as the test gage but mounted on a stress free coupon of the test material. The supplementary coupon must have the same thermal environment as the test part. Preferably it should be in physical contact, but free to expand.

Since a Wheatstone Bridge circuit, Fig. 81*a*, produces a galvanometer reading which is the difference between effects produced in adjacent arms, the spurious thermal effects cancel. Any effect due to mechanical loading and thermal stress in the test gage is not canceled. This method is suitable only when temperature gradients are small and temperature fluctuations slow, so that the temperature-compensating coupon is at the same temperature as the test-gage location.

Apparent strain sensitivity of the two gages should be very similar. This can best be determined by calibration if the temperature test body can be uniformly increased to the maximum value encountered in practice. A suitable series or shunt resistor can be used to reduce the sensitivity of the higher of the two if they are not equal. Other resistors in the Wheatstone Bridge circuit must then be adjusted to produce static balance. The strain-sensitivity factor of the active gage must be accounted for in interpreting the mechanical and thermal strains.

Use of gage materials, such as Karma, are preferable for this purpose because of their low temperature coefficient of resistivity. Correction can also be made for temperature differences between the coupon and the test body by measuring both temperatures simultaneously and applying the calibration curves for each gage.

CROSS-WIRE GAGE: Fig. 81*b*, shows a method of temperature compensation using a cross-wire gage combination. Two gage elements are mounted at right angles. They may be mounted one above the other, or adjacent.

With the two elements connected as adjacent arms of a Wheatstone Bridge circuit, the undesired temperature effects again cancel. However, since both gages are mounted on the test surface, they are sensitive to the actual strains in their respective directions. The net output represents the differences between the two strains. If the ratio of the stresses in the two directions is known, the corresponding ratio of the strains can be determined, and the strain difference readily interpreted in terms of one of the strains.

If the stress is uniaxial and the gages are oriented in the principal directions, the net reading will be greater than the major principal strain by the factor, $1 + \mu$, where μ is Poisson's ratio. Hence, this approach has definite merit for the case of one-dimensional stress, which is quite common for long beams.

As before, low temperature sensitivity is desirable. Corrections can be introduced if the temperature sensitivity of both gages are not equal.

OPPOSED GAGES: Where only the bending component of a uniaxial stress system is required, the system shown in Fig. 81*c* may be used. Both sides of the test body must be accessible, and the temperature must be constant throughout the thickness of the body. One gage is mounted on the tension surface; the other on the compression surface. The output voltage, which depends on the difference in apparent strains between the two gages, is sensitive to bending strain only. Indications due to temperature on the gages and net axial stress in the test body cancel.

RECTANGULAR ROSETTE: When the directions of the principal stresses are not known, a rosette circuit, Fig. 81*d*, may be used to determine the principal

[14]References are tabulated at end of article.

directions as well as the principal shearing strains. Gages G_1 and G_3 are oriented at ± 45 deg to G_2. Thus, the three gages comprise a rectangular rosette. Voltage V_1 provides the value of $(\varepsilon_2 - \varepsilon_1)$, while V_3 yields $(\varepsilon_2 - \varepsilon_3)$. Both readings are thus temperature compensated. If θ is the angle between the major principal direction and G_1, and ε_S is the maximum shear strain, then[15]

$$\tan 2\theta = \frac{(\varepsilon_2 - \varepsilon_3) + (\varepsilon_2 - \varepsilon_1)}{(\varepsilon_2 - \varepsilon_3) - (\varepsilon_2 - \varepsilon_1)} \quad (106)$$

$$\varepsilon_S = \sqrt{2}\,[(\varepsilon_2 - \varepsilon_1)^2 + (\varepsilon_2 - \varepsilon_3)^2]^{1/2} \quad (107)$$

If the temperature gradients in the test plane are small, the gages may be mounted side by side. The gages also may be mounted one above the other if the test surface is thick compared to the distance of the gages from the surface, and if the temperature gradient through the rosette is small. When neither of these conditions pertains, or when it is impractical to mount all gages simultaneously, triplicate tests may be conducted. Each test is conducted at the same conditions, but gages are mounted like G_1, G_2, and G_3 successively. The readings ε_1, ε_2, and ε_3 are thus separately determined, but no correction need be made for temperature since the temperature effect will later cancel when differences are taken.

Dual-Element Gage: A configuration which achieves temperature compensation by combining two strain-sensitive elements, one of positive and the other of negative temperature sensitivity, is shown in Fig. 81*e*. The amount of material for each type is chosen to produce a null effect due to temperature change when both elements are attached in essentially the same location. The dual-element gage may be obtained as separate elements or with an internal connection. Three leads should be provided so that fine adjustment of temperature sensitivity can be achieved by shunting one of the elements.

Thermocouple Gage: A final configuration, Fig. 81*f*, uses a thermocouple. Voltage from the thermocouple counteracts the undesired voltage appearing across the bridge terminals due to temperature effects in the gage. Adjustment must be provided to attenuate the output of either the gage or the thermocouple. This is done to achieve a null temperature effect in at least a limited temperature range where the temperature characteristic of the thermocouple and the gage can be equalized.

Self-Compensated Gages: The properties of a gage material—strain-sensitivity factor, coefficient of expansion, and temperature coefficient of resistance—depend on the chemical composition, heat treatment, and induced mechanical work of the gage material. Thus, there are many controllable variables which can govern the overall temperature sensitivity of a gage mounted on a given material. In particular, if the net sensitivity can be made equal to zero, a self-compensated gage can be achieved.

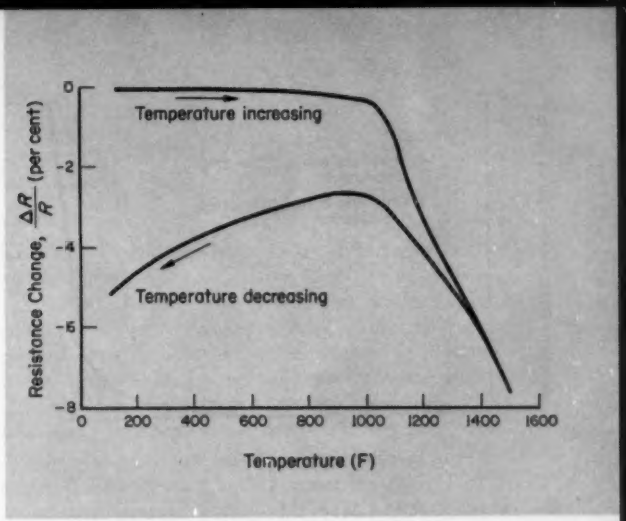


Fig. 84—Variation of resistance with temperature for a mounted Karma gage.

If $\varepsilon_t = 0$ and $\Delta R/R = 0$, the condition for self-compensation is

$$\beta_g + k(\alpha_t - \alpha_g) = 0 \text{ or } \alpha_t = \alpha_g - \frac{\beta_g}{k} \quad (108)$$

Thus, every gage is self-compensated for a material having an α_t equal to the $\alpha_g - (\beta_g/k)$ of the gage. If a number of gage material lots which vary in composition and mechanical and thermal history are selected, and if the properties for each lot are determined, information for a series of self-compensated gages is obtained.

The values of α_g, β_g and k need not be independently determined. These factors, in their proper combination, can be determined by measuring the apparent strain when mounted on any reference material. For example, Fig. 82 shows the outputs for lots *A* to *E* of Advance wire mounted on a specimen of mild steel which is free to expand so that there is no thermal stress. The apparent output is measured on an instrument calibrated for a gage of strain sensitivity k. Although the ordinate is shown as apparent strain, it equals $\Delta R/Rk = (\beta_g/k) + \alpha_{t1} - \alpha_g \Delta T$.

For lot *B*, the output is zero. Hence, lot *B* is self-compensated for mild steel. Lot *A* is not self-compensated for steel. However, from the output on the steel specimen, the material for which it will be self-compensated can be determined. If the coefficient of expansion of the material for which the lot will be self-compensated is $\alpha_{t.2}$, then $\alpha_{t.2} = \alpha_g - (\beta_g/k)$ and

$$\frac{\Delta R}{Rk(\Delta T)} = \frac{\beta_g}{k} + \alpha_{t,1} - \alpha_g = \alpha_{t,1} - \alpha_{t,2}$$

Thus, $\alpha_{t.2} = \alpha_{t.1} - (\Delta R/Rk\ \Delta T) =$ coefficient of expansion of steel minus the slope of the curve for material lot *A* in Fig. 82. Therefore, $\alpha_{t.2} = 6.0 \times$

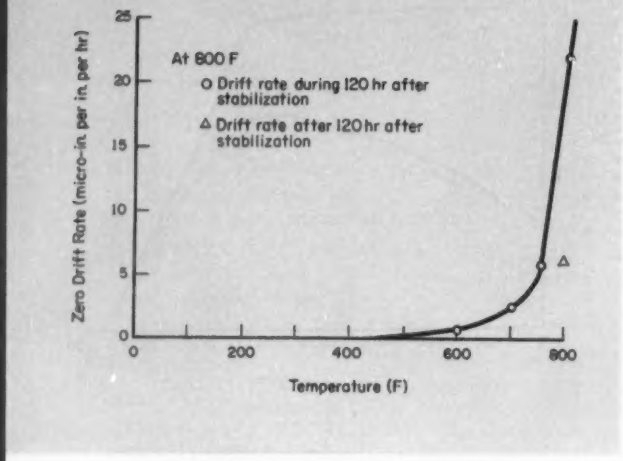


Fig. 85—Variation of zero drift rate with temperature for Karma gages.

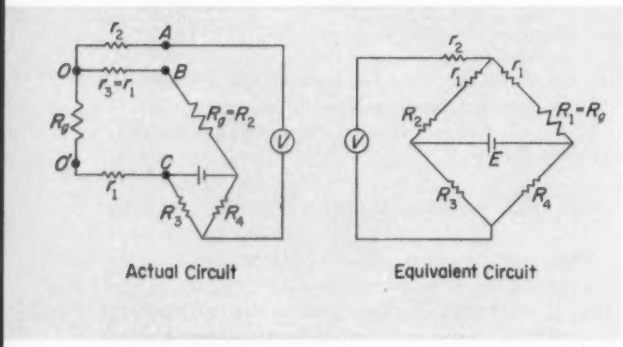


Fig. 86—Three-wire circuit for minimizing lead-wire temperature effects.

$10^{-6} - 1.4 \times 10^{-6} = 4.6 \times 10^{-6}$. This value corresponds to the value for titanium.

In a similar manner, lots *C*, *D*, and *E* are self-compensated for beryllium copper, aluminum, and magnesium respectively.

Various strain-gage manufacturers provide curves for the characteristics of available material lots to enable the user to choose the material and the lot most advantageous for a specific application by comparison with plots similar to Fig. 82. In some cases, commercial gages can be purchased which are directly designated for temperature compensation in specific materials. It should be noted, however, that the gage-material characteristics in Fig. 82 are not linear over the entire range, and that temperature compensation can at best be achieved over only a limited range. Thus, applications involving precision measurements should include calibration over the test temperature range. A combination of self-compensated gages and any of the other compensation techniques, including compensation by computation, provides the optimum precise results.

Chemical and Metallurgical Factors

When a gage is heated for appreciable periods of time, it becomes subject to certain effects: 1. Oxidation. 2. Corrosion by cement or other corrosive environment. 3. Loss of elements by vaporization or preferential oxidation. 4. Metallurgical changes.

To some extent, oxidation is inhibited by the surrounding cement. But, the cement itself may be corrosive. Loss in cross section tends to increase resistance, but preferential vaporization or oxidation may in some cases reduce the resistance. Recent developments of a new strain-gage alloy[16] are based in part on compositions with aluminum and chromium added to iron, so that the loss of aluminum, which produces a resistance increase (due to cross-section effects) and a resistance decrease (due to change of resistivity), yields a low net resistance change, Fig. 83.

Effects 1, 2, and 3 can be reduced by using gages that have as large a volume-to-surface ratio as possible. This implies a heavier cross section. Also, the surface reactions will be more rapid at first, and then diminish in rate as the oxidation or corrosion product develops a protective film. Thus, a period of stabilization is very desirable prior to undertaking strain measurements. Hence, a soaking period of at least 50 hours at 700 to 750 F for Karma gages has been recommended prior to undertaking static-strain measurements.[17]

Metallurgical instabilities should be avoided during the test, since they are frequently accompanied by very large changes in resistivity. For Karma, a transformation takes place at approximately 800 F, Fig. 84. The resistance of a 0.001-in. Karma wire is plotted as a function of temperature. The temperature was gradually increased from room value to above the transformation value. Up to approximately 1000 F, the increase in resistance per degree was very small. This is the reason for the excellent performance as a static-gage wire material. At the transformation temperature (1000 F for this sample), the resistance changes drastically. Further use of the material, even if the temperature is decreased below the transformation value, makes the gage essentially useless for static thermal-stress measurements. Thus, it is important to avoid exceeding certain temperature limits, even for short time periods, when dealing with materials that involve metallurgical instabilities.

Since corrosion is a time-dependent phenomenon, the correction required depends on how long the gages must be subjected to the corrosive environment while the measurements are being made. The zero drift, due to corrosion, is very nearly linear with

time. Hence, determining the rate of drift is sufficient for correction purposes. Fig. 85 shows the rate of drift as a function of temperature. This drift is extremely low below 600 F. At 800 F it is fairly high, but can be tolerated if the test times are low. Two data points are shown at 800 F, the higher value refers to the initial drift in the first 120 hours, while the protective film is being formed, the lower rate corresponds to the period after stabilization.

Stability of resistance depends largely on the cement which protects the gage material from the environment, but which itself may cause chemical attack. Numerous adhesives are available. The choice of which to use depends on the highest temperature expected during the measurements. The lowest temperature cement which is suitable for the application should be chosen, since the lower the temperature limitation the greater the ease of application and reliability.

For low and moderate temperatures to 200 F, conventional cellulose-nitrate cements are quite satisfactory. Curing is achieved by heating. This causes the solvent to escape gradually preventing bubbles from developing to reduce the bond. The gage should be cured at approximately 140 F until resistance between gage and test surface reaches 10,000 megohms.

For rapid installations, cyano-acrylate resins may prove satisfactory. This cement requires a catalyst which, under contact with mild pressure, produces a bond of unusual strength. The installation can be used almost immediately, although a 24-hour cure at 105 F greatly improves the bond strength. Its primary use is in the neighborhood of room temperature. This cement has not been considered suitable above 110 F. Also, it has not been evaluated for low-temperature work.

For moderate temperatures up to approximately 350 F, the phenolic resins have a long record of success. Curing by heat and pressure, and postcuring at a higher temperature minimizes drift. Phenolics have a relatively short shelf life.

Epoxy resins have also been used in the moderate-temperature range and are superior in some respects to the phenolics. These adhesives cure by a chemical process when a hardener is added. The shelf life is indefinite, since the curing does not start until the hardener is added. No volatile product is produced during curing that must be vented, and under proper conditions a high bond strength is obtained. Temperature curing is not necessary for some of the epoxies, although greater stability is achieved with curing. On the other hand, epoxies have a high coefficient of expansion (which can be moderately reduced by additions of suitable fillers), and their installation is sensitive to the proportions of filler and hardener, curing temperatures, and other factors. Thus, greater care in installation and prior calibration are needed if the superior qualities of the epoxies are to be achieved. Combinations of epoxies and phenolics have also been used to increase service temperatures.

For temperatures above 600 F, only the ceramic adhesives have received sufficient study up to the present time to warrant consideration in thermal-stress applications. Numerous cements are available, although none has been developed specifically for strain-gage application.

When the temperature characteristics of the test material permit, a ceramic precoat is useful. Use of ceramic precoat is limited, however, since a firing temperature of 1750 F is required.

Stability and reproducibility of the ceramic cements can also be greatly increased by ball milling for 48 hours, using porcelain balls, and by altering the phosphoric-acid content to an optimum amount which is experimentally determined to yield good adhesion, ample hardness, and resistance to abrasion and cracking. Ceramic adhesives are best applied by spraying with an air brush, drying for several hours at 150 F, and baking for ½ hour at 600 F. Karma-wire gages, mounted with these cements, have been found very suitable for thermal-stress measurements up to temperatures of about 800 F.

Lead-Wire Considerations

For electrical connections between the strain gage and electrical instrumentation, two important considerations affect the choice of both materials and configuration within the circuit for lead wires.

1. Thermoelectric voltages generated at junctions of dissimilar metals subjected to temperature changes. These voltages can add to the voltages induced in the measuring circuit by resistance changes in the strain gages. Hence, they could completely mask the stress effect to be measured. The simplest method of avoiding these spurious effects is to use spot-welded lead wires of the same material as the strain gage thereby avoiding all junctions of dissimilar metals. For example, gages of 0.001-in. Karma wire have been followed by ½-in. leads of 0.010-in. Karma, which, in turn, have been followed by a secondary lead of 0.025-in. Karma of sufficient length to reach a point which is essentially at room temperature. At this point the wires are joined to copper for connection to instrumentation.

2. Resistance changes due to changes in temperature of the lead wire. Both Karma and Nichrome V wire, which have most commonly been used as gage elements, have high specific resistivity. Nichrome V has a temperature coefficient of resistance of approximately 50×10^{-6} per deg F while this coefficient for Karma is 10×10^{-6} per deg F.[18] In Nichrome V installations, appreciable resistance changes in the leads may be expected if the temperature changes involved are several hundred degrees. Even for Karma, the resistance changes are

sufficient to warrant consideration when long lead wires and large temperature ranges are involved. In one solution, heavy-gage lead wires are used. These minimize the parasitic resistance, and therefore the resistance changes due to temperature effects.

Another approach uses the three-wire lead-out system, Fig. 86. Lines *OA* and *OC* represent resistances r_2 and r_1 in the lead wires between the gage and remote points at sufficiently low and uniform temperature to permit dissimilar-metal contact. A third lead *OB* which is identical to *O'C* is added, and the circuit is arranged as shown in Fig. 83*a*. Thus, r_1 enters into two adjacent arms of the Wheatstone Bridge and has no perceptible effect, even if varied over a fairly wide range. Resistance r_2 appears in the output measuring circuit which is of high impedance so that temperature effects can readily be tolerated.

If the bridge is initially balanced, $R_3 \approx R_4$, a change in the gage resistance ΔR_g produces a change in voltage ΔV. Hence,

$$\Delta V = \frac{(\Delta R_g)E}{4(r_1 + R_g)} \qquad (109)$$

Since gage factor $k = \Delta R_g / R_g \epsilon$,

$$\Delta V = \frac{k' E \epsilon}{4} \qquad (110)$$

where

$$k' = \frac{k}{1 + \frac{r_1}{R_g}} \qquad (111)$$

Thus the effect of r_1 is to desensitize the gage by the factor, $R_g/(r_1 + R_g)$, even though small changes in r_1 do not appear as output signals. For this reason, it is desirable to keep r_1 as small as possible, and to set the measuring equipment to the gage factor obtained from Equation 111.

The next article in this series will discuss the practical applications of strain gages for measuring thermal stresses.

REFERENCES

This article is the fourteenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .. June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958
4. "Causes of Fatigue in Ductile Materials" .... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ..... March 19, 1959
11. "Stresses Under Plastic Flow and Creep" ..... July 9, 1959
12. "Plastic Stresses and Strains by Successive Approximations" ..... July 23, 1959
13. "Incremental Solutions for Plastic Stresses and Strains" ..... August 6, 1959

Other references mentioned in this article are:

14. W. H. Graft—"Development of High Temperature Strain Gage Wire," ASTM, *STP No.* 230, page 76.
15. S. S. Manson—"An Automatic Electrical Analyzer for 45 deg Strain Rosette Data," *NACA TN* 941, May, 1944.
16. Arthur G. Metcalfe—"The Stability of Strain Gage Alloy Wires," ASTM *STP No.* 230, page 109.
17. Richard H. Kemp—"Advances in Static and Dynamic High Temperature Strain Gage Research," ASTM *STP No.* 230, page 18.
18. James E. Starr—*Electrical Strain Measurements at High Temperature*, ASM.

Tips and Techniques

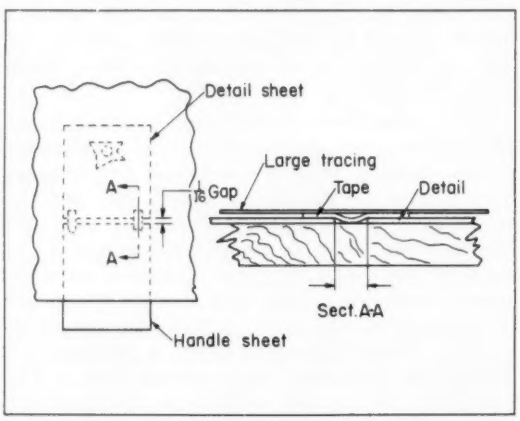
Weld-Bead Strength

Weld-bead size for a joint which must resist a shear force is easily figured by the following memory aid. To arrive at the approximate strength of a given bead size, change the decimal equivalent of the fillet in inches to the nearest thousand pounds, using the first four digits of the decimal. For instance, a 3/8 fillet is 0.3750 in. or 3750 lb per inch of length. Shown in the table are the values recommended by the American Welding Society for the various bead sizes.—EDMUND L. WIZA, *designer, Minneapolis-Honeywell Regulator Co., Ft. Washington, Pa.*

Fillet Size	Fillet Strength	Decimal Equivalent
1/8	1200	0.1250
3/16	1800	0.1875
1/4	2400	0.2500
5/16	3000	0.3125
3/8	3600	0.3750
1/2	4800	0.5000
5/8	6000	0.6250
3/4	7200	0.7500

Handling Detail Sheets

When tracing a small detail on a large drawing, a 1/16 in. gap between two sheets of paper enables the draftsman to locate the details under the large tracing and to tape it down. This limited area of tape adhesion between the detail sheet and the "handle" sheet permits easy removal, while preventing shift during tracing.—LEONARD HELLER, *principal engineer, Republic Aviation Corp., Mineola, N. Y.*

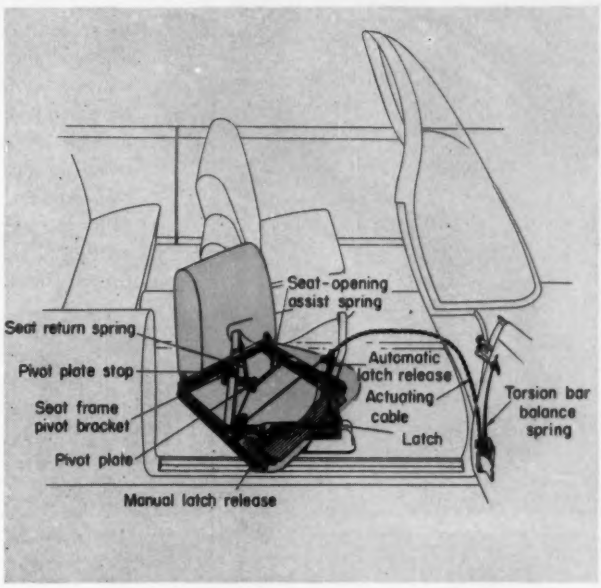


Seats Swivel Automatically and Doors Lock by Vacuum in '60 Dodge

SPRINGS AND CABLES TURN the front seat when the front doors are opened on the 1960 Dodge. Each seat automatically swings back when the door is closed.

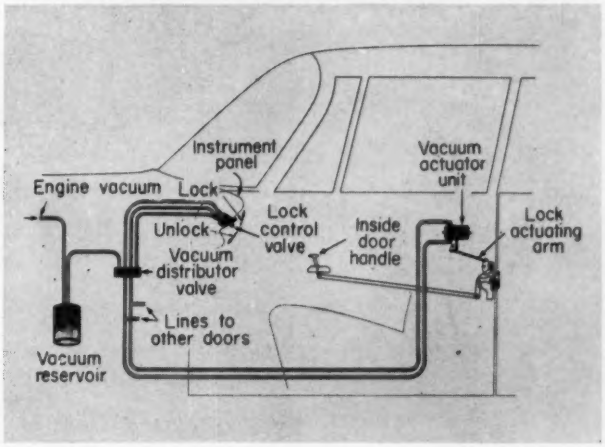
In design, one end of the seat-actuating cable is attached to the door and the other end to a pivot plate under the seat. Two springs are also attached to the pivot plate. One spring, which is lighter than the other, is hooked to the seat proper. The heavier spring is fastened to the seat frame. A torsion-bar balance spring attached to the door hinge counteracts the pull of the two springs so that the door-opening effort is unaffected.

When the car door is opened, the cable pulls the plate outward, stretching both springs. A second cable, attached to the actuating cable, releases the seat latch when the door is about half open, and the light spring swivels the seat outward until the pivot-plate stop contacts the seat frame pivot bracket. When the door is closed, the heavy spring pulls the swivel seat back until it latches in the straight-ahead position.



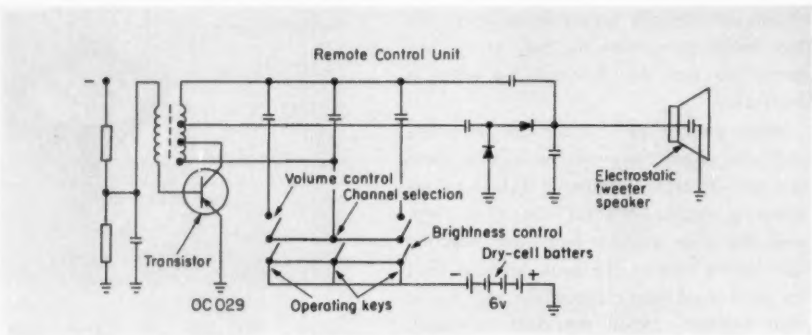
VACUUM-POWERED LOCKING SYSTEM locks all doors in the new Dodge by the touch of a lever located near the driver on the instrument panel. The doors can all be unlocked simultaneously with the same lever, or each may be unlocked individually from the inside. The front doors can also be locked or unlocked with the ignition key from outside the car.

Vacuum actuators located inside the door and body panels provide positive locking action. When the lock lever is flipped to the lock position, engine vacuum supplies the power to lock the door mechanism. When the lock lever is in the neutral position, the doors are automatically locked after engine manifold pressure drops below 7 inches hg. A vacuum reserve tank on the engine firewall permits locking and unlocking the doors several times after the engine has been turned off.



Ultrasonic Signals Control TV Set

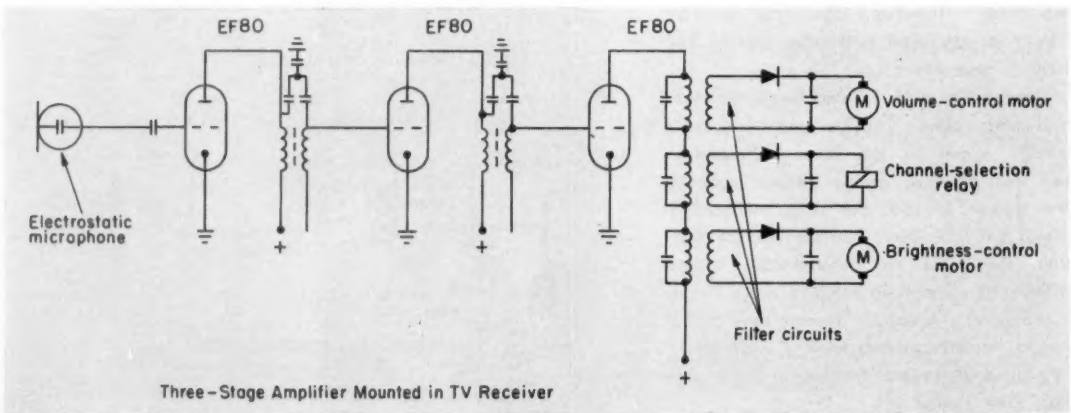
TRANSISTORIZED MINIATURE TRANSMITTER emits ultrasonic signals of three different frequencies for remote control of TV receiver volume, channel, and brightness. Powered by four 1.5-v dry cells, the 7-oz transmitter is designed with a single OC 029 transistor. When one of three operating keys is depressed, a corresponding frequency is generated by an oscillator and emitted through an electrostatic tweeter speaker. Auxiliary voltage required for the speaker is produced from supersonic frequencies by two rectifiers. Frequencies used are 19 kc for volume control, 28 kc for channel selection, and 23.5 kc for brightness control. The remote control unit is a development of Grundig Radio-Werke GmbH, Fuerth/Bay, Germany.



ELECTROSTATIC MICROPHONE in TV set feeds signals into tube-equipped three-stage amplifier. After third stage, operating frequencies are filtered out and rectified by individually tuned circuits.

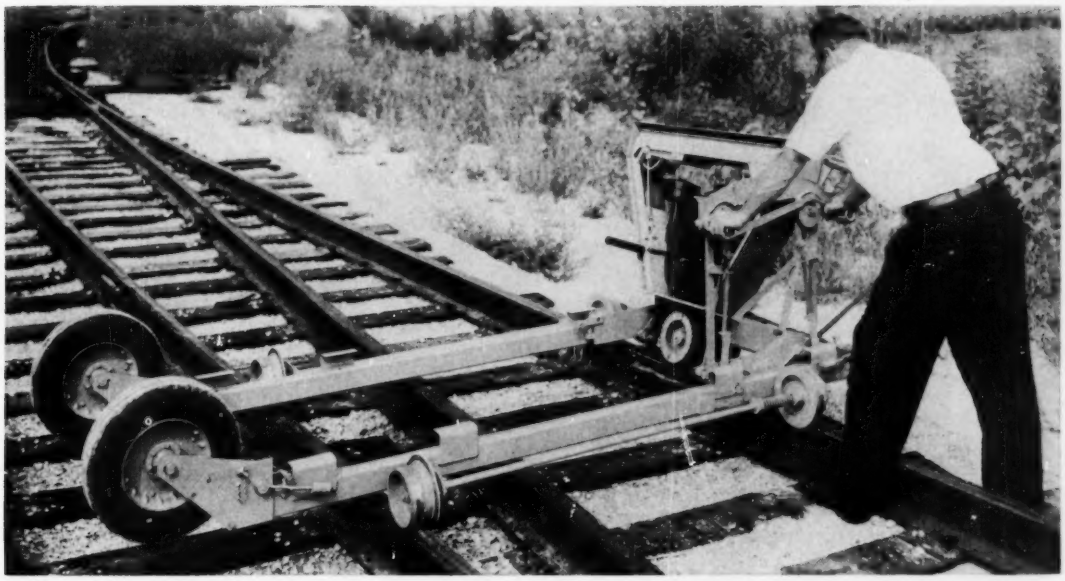
Dc control voltages for volume and brightness are fed to two small motors which drive corresponding potentiometers. Since gear-train sense of rotation is automatically reversed with each new pulse, volume and brightness can be adjusted through remote control as well as by hand. Control voltage for channel selection actuates a relay, the contacts of which are parallel to the set's manual selection key normally operating the motorized channel selector.

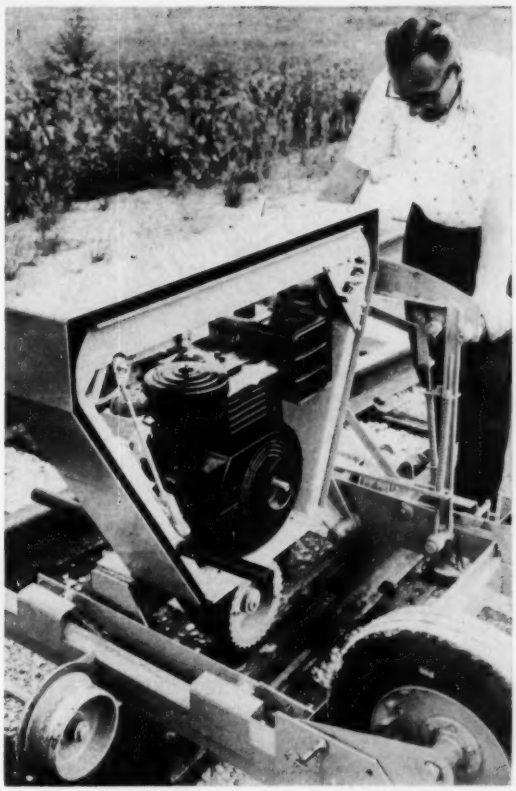
The plastic-housed control weighs 7 oz.



Three-Stage Amplifier Mounted in TV Receiver

Grinding Belt Encircles Engine Drive





CONTOUR GRINDING of rail ends is easily accomplished by a new, abrasive-belt rail grinder. Developed by National Cylinder Gas Div., Chemetron Corp., this machine is the first portable, rail-surface grinder to utilize a continuous abrasive belt. With this machine, one man can contour grind rail-head surfaces, smooth rails which have been reconditioned by welding, or remove "secondary rail-end batter" from bolted rail joints.

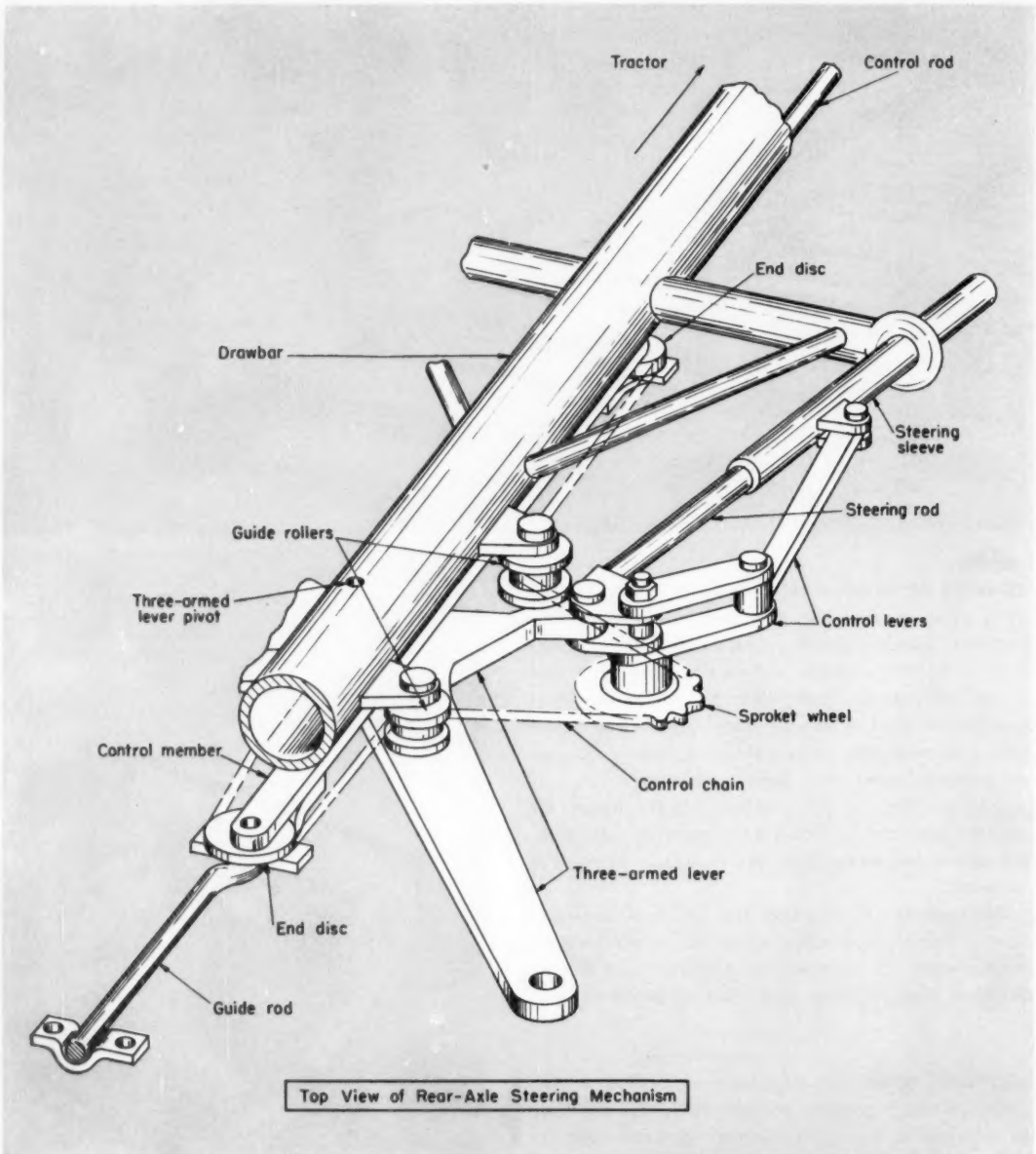
The operator, holding handlebar grips, moves the machine back and forth during the grinding. The grinding unit is adjustable from side to side in its carriage assembly.

The machine can be lifted from the track in wheelbarrow fashion and rolled away on 16-inch, rubber-tired wheels. If required, the grinding head can be detached from the frame and lifted off separately.

BELT DRIVE POWER for the grinder comes from a four-cycle, air-cooled gasoline engine. A flexible shaft can be attached to the engine for driving a rail slotter or other accessory equipment.

The 24-grit belt, which is 4 in. wide and 106 in. long, is mounted on three rollers to form a triangle. The contact wheel is made of flexible material, permitting the moving belt to shape itself to the contour of the rail head.

Steerable Rear Wheels on Trailer



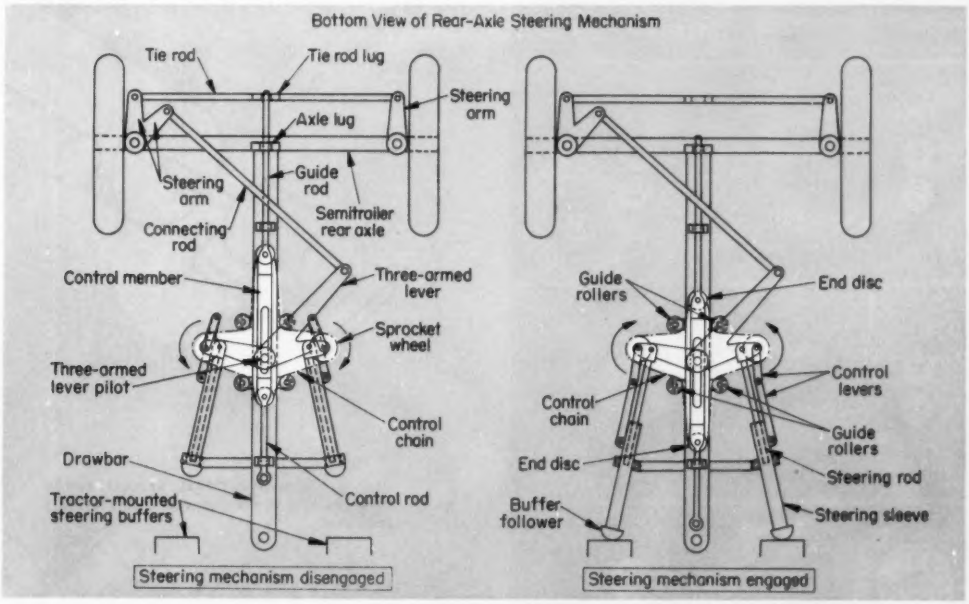
Top View of Rear-Axle Steering Mechanism

TRACTOR-MOUNTED BUFFERS operate lever mechanism to steer semitrailer rear wheels during backing of tractor-trailer rig. In reverse maneuvering, two buffers engage with two buffer followers on the rear-wheel steering mechanism. The buffer followers mounted on steering sleeves actuate the connecting rod to the rear wheels through steering rods.

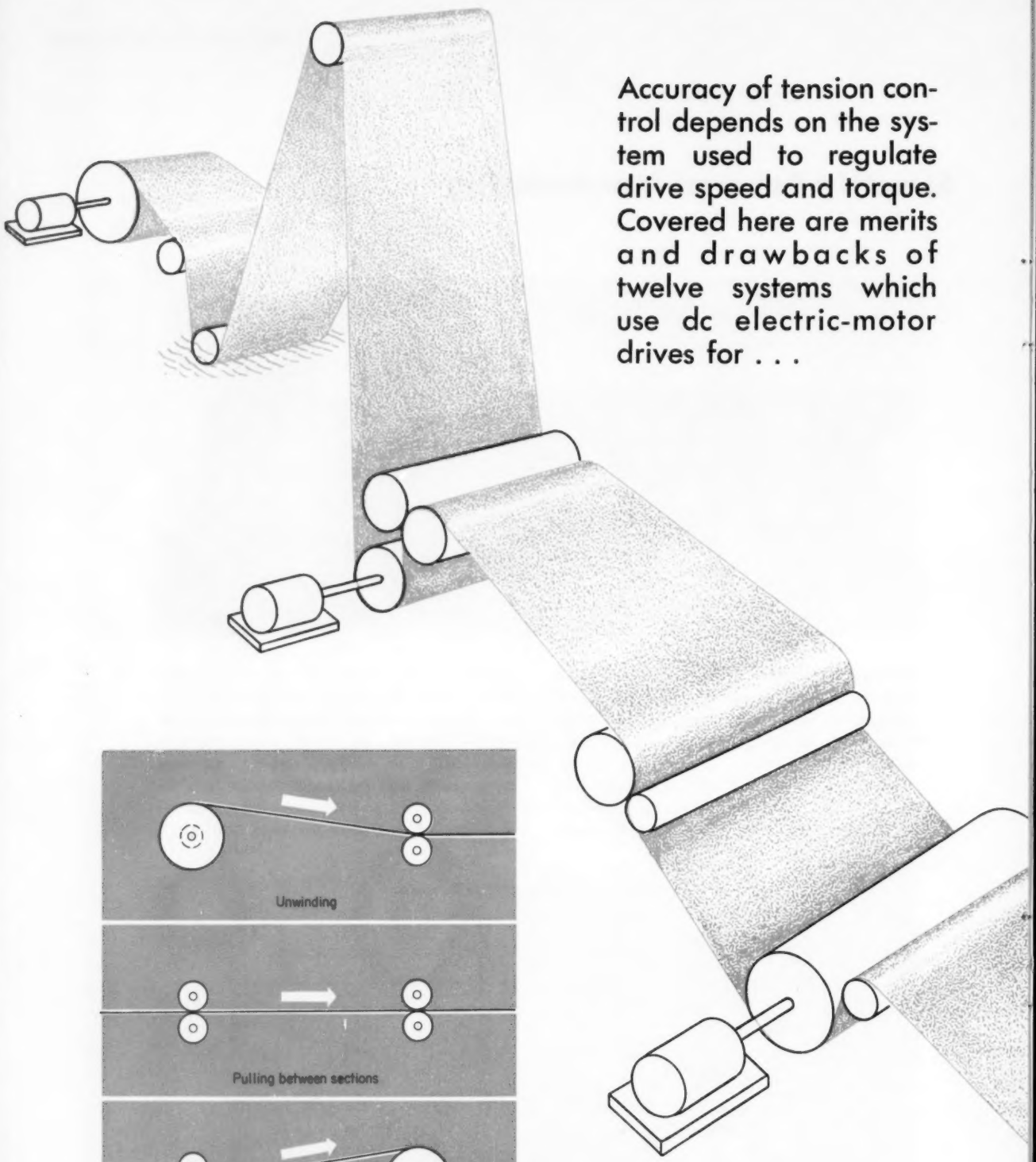
Simplify Reverse Maneuvering

STEERING MECHANISM is designed to be "set" in either of two end positions by a slotted control member sliding along the drawbar. The control member connects to a tractor-mounted actuator through a control rod.

As the control member is electropneumatically pulled toward the tractor for reverse maneuvering, a roller chain turns two sprocket wheels. Turning with the wheels are two control levers which engage the sleeves and buffer followers with the tractor-mounted steering buffers. In the engaged position, the control levers lock the mechanism. In the disengaged position, the guide rod extending from the control member locks the rear-axle tie rod. Steering mechanism is a design of Christoph Dinkel, Wertheim/Main, Germany.



Accuracy of tension control depends on the system used to regulate drive speed and torque. Covered here are merits and drawbacks of twelve systems which use dc electric-motor drives for . . .



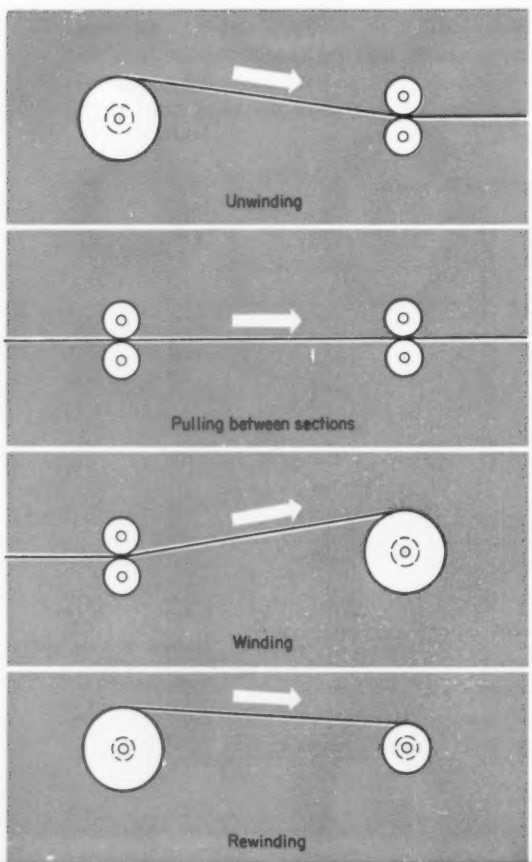


Fig. 1—Four functional process conditions in which tension control is usually required.

Controlling Web Tension

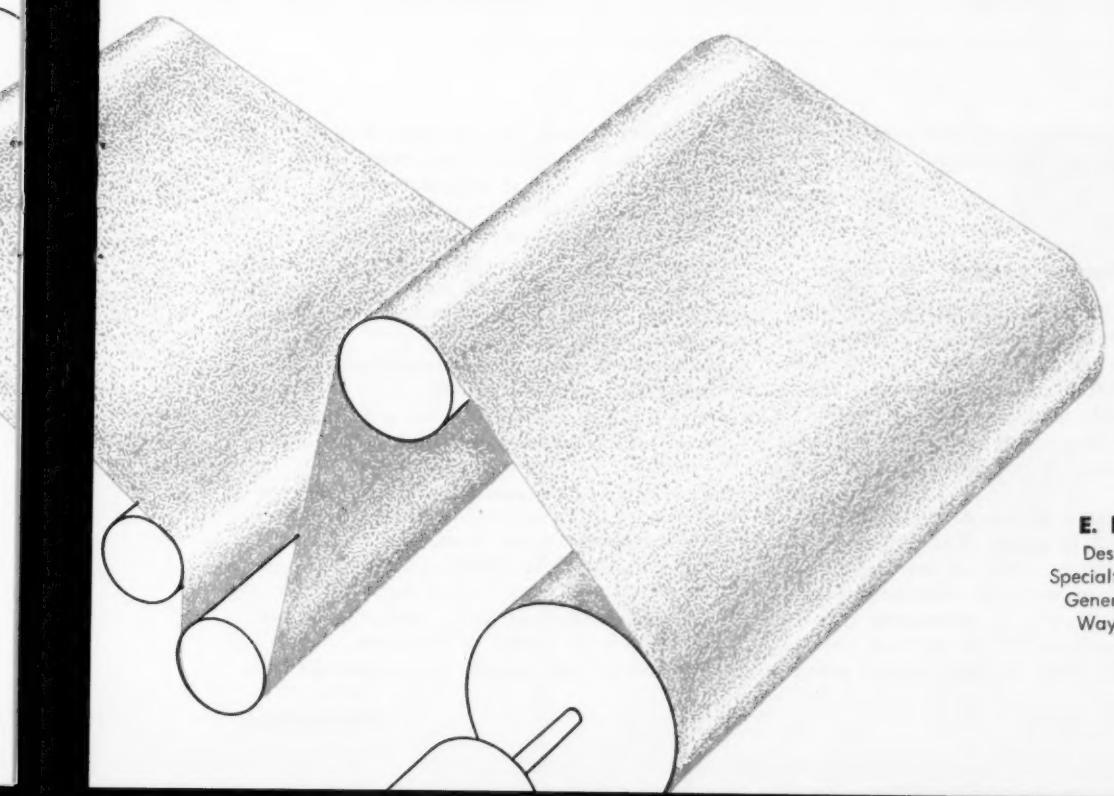
A WHOLE host of drive and control systems have been developed to regulate tension in moving webs or sheets. The system selected for a given application depends primarily on the physical characteristics of the material, process requirements, and accuracy of tension control.

Obviously, web-material characteristics are of major importance in designing a tension-control drive system. How much a material can be safely stretched must be known.

Also, it must be recognized that strength characteristics of materials may vary at different stages in processing. For example, wet paper leaving the couch section of a paper machine has practically no strength but can be stretched some. The same paper, after it is dried, can take several pounds of tension during winding but will stretch little. When the paper is wet, accurate drive speed control rather than tension control is required to obtain proper weight and quality of paper. After the paper reaches a dried condition, accurate tension control is needed to wind the paper on the reel tightly but not break it.

Material characteristics often dictate whether web tension can be sensed directly or indirectly. For example, a roller-type device for direct sensing of tension may damage fragile web material. In such a case, an indirect means of tension detection will be required, such as electrical sensing of drive-motor torque.

So far as process requirements are concerned, as shown in Fig. 1, there are only four: 1. Unwinding. 2. Continuous pulling between sections. 3. Winding.



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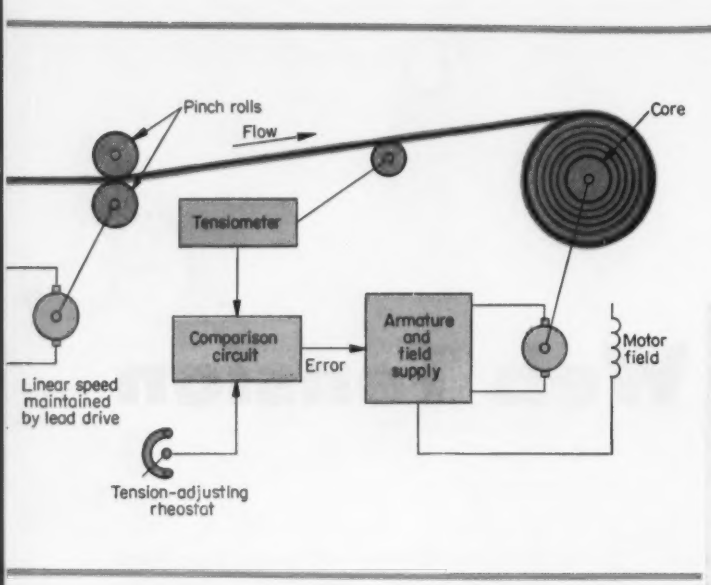
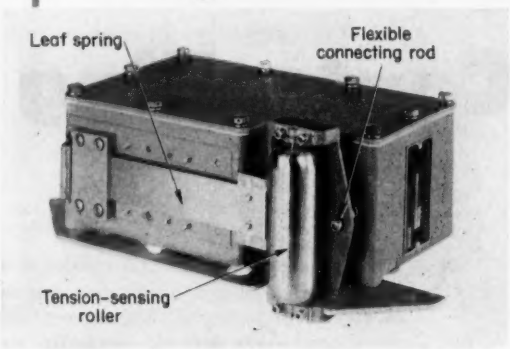
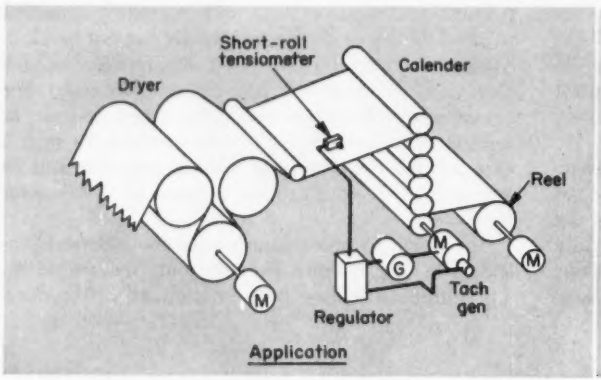
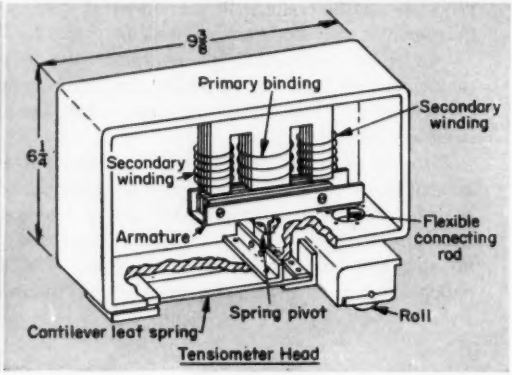


Fig. 2—A system for direct tension control of a center-wind windup. In operation, armature voltage is gradually increased to rated, and then the field is progressively weakened as required to hold tension. Stall-tension control and inertia compensation are inherent.

Fig. 3—Differential-transformer pickup used for tension sensing and control in Fig. 2.







4. Rewinding. This article concentrates primarily on windup systems, although unwind and rewind systems are also covered.

Differential-Transformer Control

Shown in Fig. 2 is a center-wind windup drive with a differential-transformer device used for direct tension feedback to the control. Fig. 3 shows one type of differential-transformer sensing and feedback device commonly used in the paper industry. A similar tension-sensing unit is used in the steel industries to control tension between stands on two-stand temper mills.

The adjustable-tension reference in Fig. 2 is obtained from a dc voltage supply. The difference, or error, between the tension reference and the actual tension feedback voltage from the differential-transformer sensor is obtained in a comparison circuit. The output of comparison circuit is sent to a voltage and power amplifier which in turn supplies power to the windup motor. The sequence of operation is such that, as a function of the error voltage, the armature voltage is first increased to rated value after which the field is progressively weakened to maintain tension. To simplify the stabilizing problem, the control may be arranged to provide armature control even in the field range for rapidly correcting for tension errors with the field assuming its proper value more slowly.

Advantages of the differential-transformer control method of tension control include:

1. High degree of accuracy of tension control since the actual value of tension is continuously monitored and corrected.
2. Tension can be maintained during acceleration and deceleration of the strip without the need for a separate inertia-compensation circuit.
3. Stalled tension can be directly controlled at all times without the need for a "memory rheostat."
4. Accuracy is maintained despite changes in material characteristics or changes in drive losses.
5. The tension meter indicates and monitors the ten-

sion value actually being maintained. If the main line drive is provided with linear timed acceleration and deceleration control, the accuracy of tension during line-speed changes will be further enhanced.

Disadvantages of the differential transformer are:

1. Somewhat greater stabilizing problem, particularly at high line speeds and large build-up ratios.
2. Mechanical problems of mounting.

In addition, for wide tension adjustment, readjustment of the spring tension in the tension meter is required.

Weight-and-Loop Control

Another method of direct tension control involves the use of a floating roll supported by a straight-sided loop of the material being processed, Fig. 4. Mechanically connected to the roll are a weight representative of the desired tension and a device for providing an electrical signal indicative of loop position, such as the variable-core reactor shown.

For the single loop shown, the total tension in the web is half the combined weight of the roll, the indicating device and the added weight, with the latter normally providing the largest part of the total. Tension can be changed by increasing or decreasing the external weight. In some cases, a series of loops and rolls or "festoons" are used with a resulting increase in material or "storage" in this section. One purpose of increased storage would be to permit stable operation at high linear speeds. Another would be to provide temporary material storage where the main drive must not stop during the changing of the windup reels.

This method of tension control involves the control of the position of the loop. The relationship between the length of travel of the position-sensing device and the output of the motor-field supply panel affects obtaining satisfactory, stable operation over the whole buildup range. In general, longer travel and more loop storage make the control problem easier. Also, the amount of travel and storage required are roughly proportional to web speed.

The primary advantage of this system is that the average amount of tension being held is positive and directly controllable. Also, stalled tension can be maintained at the same value as running tension, and the system provides an additional material storage function as noted earlier.

Disadvantages of the loop tension control include the initial expense and required maintenance of a mechanical system, and threading problems. Also, tension adjustment requires changing weights and tapered tension cannot be achieved electrically although it can be provided mechanically in some cases.

Tension can be held relatively constant during periods of acceleration and deceleration of the main drive, and if the rate of speed change is not too high, a separate inertia-compensation function is not required.

Although the arrangement shown in Fig. 4 is one commonly used, design variations can be made to meet material or process requirements, machine specifications, or to permit integration with other electrical equipment. The armature-voltage source for the pinch rolls can also supply voltage to the armature of the windup motor since these voltages must be approximately proportional if a separate field

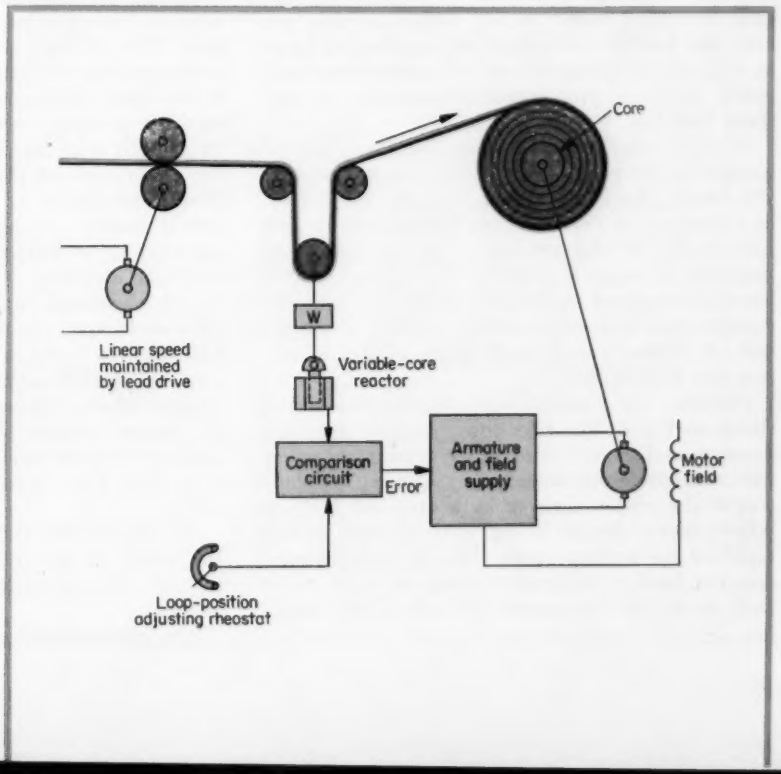
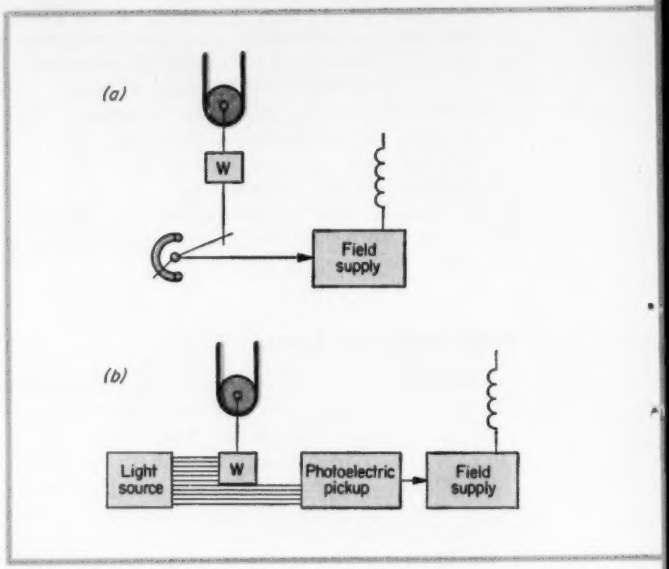


Fig. 4—A method of direct tension control for center-wind drives using a loop of material and a weight on a roller to establish tension. A variable-core reactor pickup is attached directly to the weight. The system has inherent stall-tension control.

Fig. 5—Two methods of converting loop position into an electrical control signal. In *a*, the weight is mechanically connected to a control rheostat, and in *b* the weight interrupts a beam of light falling on a photoelectric pickup.



supply is used. The sequence of control would be, as usual, the adjustment of armature voltage to rated and then field weakening as required.

In addition to the variable-core reactors, other loop-position signal devices may be used, Fig. 5. Because of wear resulting in periodic replacement, the potentiometer has in the past generally not been considered wholly satisfactory for this purpose. However, several low-torque, long-life, linear-motion potentiometers now available make this electrically simple device much more attractive as the position-sensing element.

The photoelectric scheme has particular advantages when the tension to be maintained is small. The weight can be replaced by a lightweight target, and, at times, both the loop roll and the weight are eliminated entirely. Sometimes the loop itself is used to intercept the light beam and provide position indication. This requires, however, that the material be opaque. The tension then is the minimum value provided by the weight of the material itself.

Rider-Roll Control

Unlike the two previous systems in which direct control of tension is possible, the loop rider-roll method, Fig. 6, controls tension by controlling motor torque. For a windup section, the tension component of motor developed torque equals material tension times roll radius.

If the tension component of torque could be measured directly, it would be easy to control tension. Unfortunately, this is difficult to do. However, the total developed motor torque, which includes not only the tension component but mechanical losses as well, can be measured and controlled. Developed motor torque is proportional to armature current times field flux.

Since the relationship between field flux and field current for the particular motor is usually available, the motor developed torque can be programed, as a function of roll diameter, by programing field current. If, for the moment, frictional losses are neglected, a means is available for holding constant tension throughout the buildup range. If, in addition, compensation is made for frictional losses as a function of windup motor speed, closer control of tension can be obtained.

Provision for frictional-loss compensation is not shown in Fig. 6. The rider roll is used to sense roll diameter and rotate a rheostat for programing motor field strength, either directly as shown with a rheostat of the proper taper or by a cam and a linear potentiometer. Shape of the cam controls tension taper for the buildup range. Also, the field rheostat does not have to be directly connected in the motor field circuit but can operate through a field amplifier.

Armature current is maintained by operating the armature power supply on current limit with the current-limit potentiometer, which serves as a tension adjustment. The rider roll is shown as operating a second potentiometer for providing the inertia-compensating function which is also a function of roll diameter.

As explained previously, inertia compensation adds accelerating torques temporarily during periods of acceleration and deceleration of the web. In Fig. 6, the second potentiometer on the rider roll provides an inertia-compensation signal which is sent to the armature circuit as an added armature current reference. This reference is used to recalibrate armature-current periods of changing web speed. For example, if web speed is controlled by a motor-operated rheostat, the armature-current inertia-compensation signal is built in as a function of the relays controlling the motor-operated rheostat. Compensation thus applied is referred to as "block inertia compensation," and it develops the torque component necessary for accelerating or decelerating the roll inertia at that particular diameter.

The advantages of this system include reasonably accurate tension control over a buildup range as high as 4 to 1 and a wide linear speed range. The range of tension adjustment with accurate control depends on the relationship of mechanical-loss torque to tension torque. Acceptable accuracy can be achieved in most cases for a tension adjustment of 4 or 5 to 1 or more if loss compensation is provided.

The major advantage of the circuit in Fig. 6 is the ability to adjust tension with a potentiometer instead of by changing weights or adjusting spring tension.

The primary disadvantage is a mechanical one and

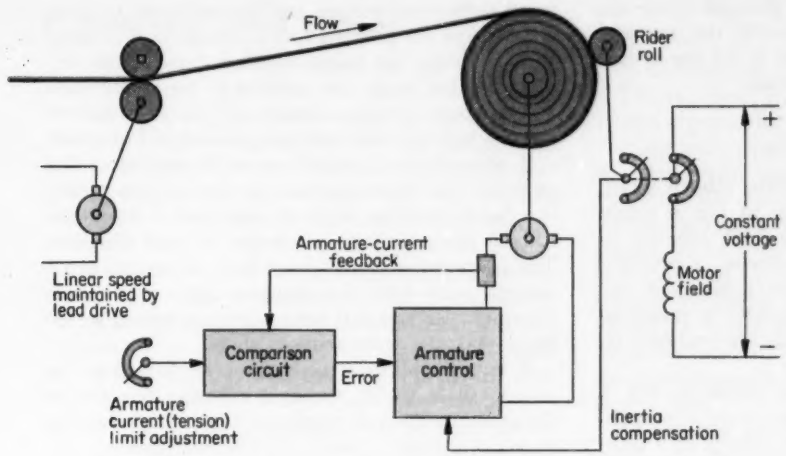


Fig. 6—A system of indirect tension control for a center-wind drive using a rider roll. Drive-motor torque depends on the positions of both the armature-control rheostat and the field-control rheostat.

CONTROLLING WEB TENSION

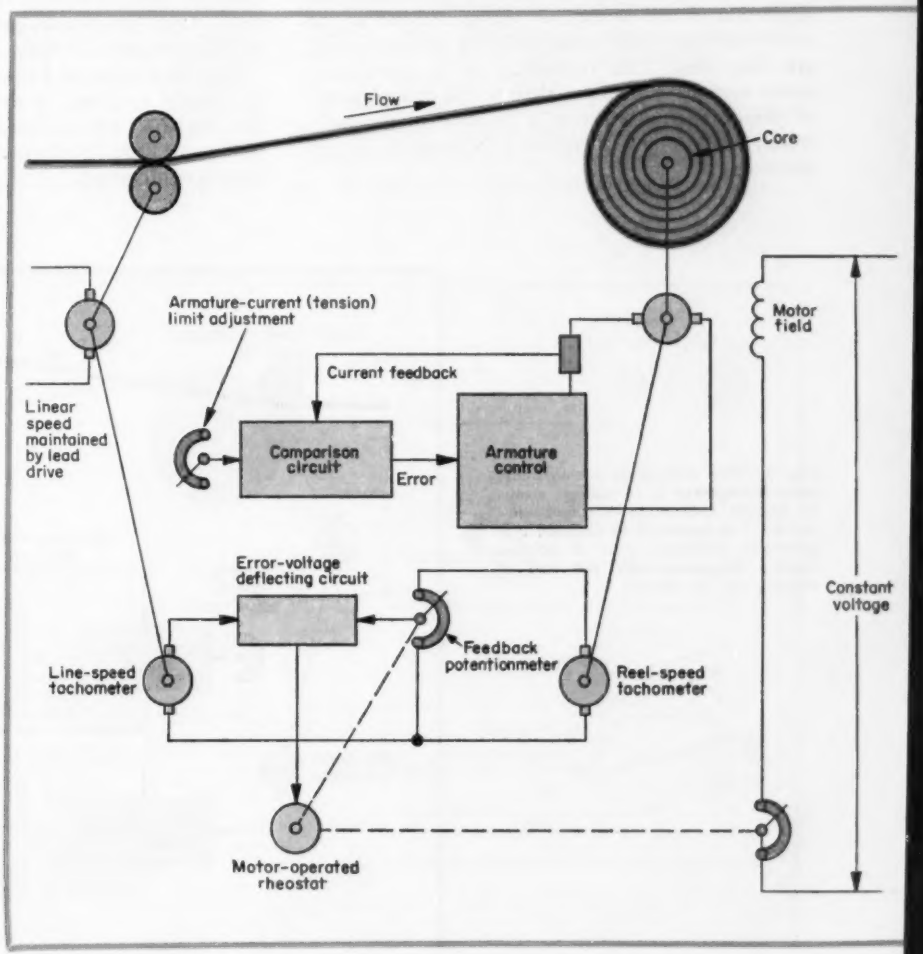


Fig. 7 — An indirect method of tension control in a center-wind drive which senses drive-motor torque through a dropping resistor in the armature circuit. Line-speed and reel-speed tachometers measure reel diameter indirectly.

concerns the rider roll itself which is a source of additional cost and maintenance. It also presents operating problems when rolls are changed. Since the rider roll is in direct contact with the material and must exert some pressure on it, its use is precluded in handling certain materials.

Dual-Tachometer Control

In Fig. 7 is a roll-diameter sensing scheme which is similar to the rider roll system in Fig. 6 except the rider roll is eliminated. The basic function of the rider roll, that of sensing diameter, is provided by a system which compares the voltages of two tachometers, from which the diameter is measured indirectly. No direct contact with the material on the reel is required.

The tachometer error-detecting circuit in Fig. 7 compares the total output voltage on the line-speed tachometer with a portion of the voltage of a tachometer coupled to the reel. If these two voltages are not equal, the error-detecting circuit actuates a motor-operated dual potentiometer in the direction necessary to reduce the voltage difference to zero. One plate of the potentiometer is connected across the reel tachometer. As the reel builds up in diameter, the reel tachometer will slow down progressively and the error circuit will operate to increase the proportion of reel-tachometer voltage applied to the error-detecting circuit to maintain the difference voltage near zero. This regulating action provides a rotary motion—the output shaft of the motor-operated potentiometer, which is a function of reel-tachometer voltage and therefore is a function of reel diameter.

Since the detecting circuit acts to maintain zero error and since, for a given reel diameter, the line-speed tachometer voltage and the reel-speed tachometer voltage are proportional, a change in line speed will not bring the motor-operated rheostat into action. In other words, the position of the output shaft of the motor-operated rheostat will be a function of the reel buildup alone and independent of line speed.

If an additional potentiometer is coupled to the output of the motor-operated rheostat, whose motion is a function of reel diameter, the field of the motor can be programed as a function of reel diameter. The programing device could be a direct-connected potentiometer with the required taper or a linear potentiometer operated from a cam connected to the motor-operated potentiometer shaft.

A second additional potentiometer coupled to the output shaft could, through suitable circuitry to the armature control, supply an inertia-compensation signal, which is a function of diameter also.

A further refinement of the system could include a compensation for frictional losses which are a function of reel speed alone and are essentially independent of diameter. The frictional-torque compensation would be supplied most conveniently as a modification of armature current. A fourth potentiometer coupled to the motor-operated potentiometer could be used to modify the armature current supplied at any particular speed and would make this modification as a function of reel diameter.

The advantages and disadvantages of this system are similar to those for the rider-roll system except that the rider roll is eliminated. The regulator and tachometers are functionally equivalent to those for the rider-roll system.

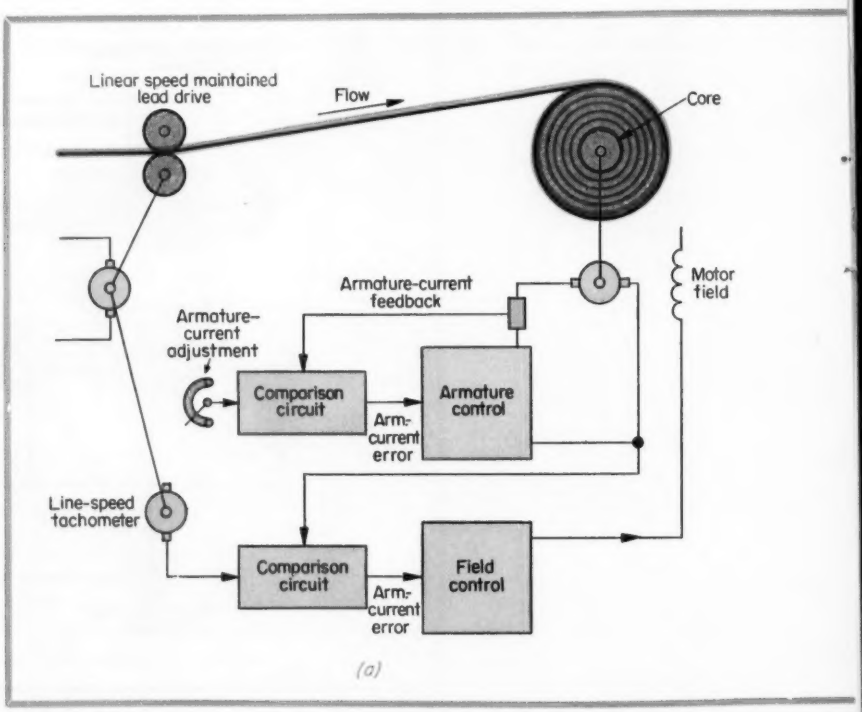


Fig. 8—Two techniques for utilizing drive horsepower as an indirect means of tension control in a center-wind drive. The approach in diagram *a* is generally preferred over *b* because tension decreases near the end of windup in the latter.

Horsepower Control Methods

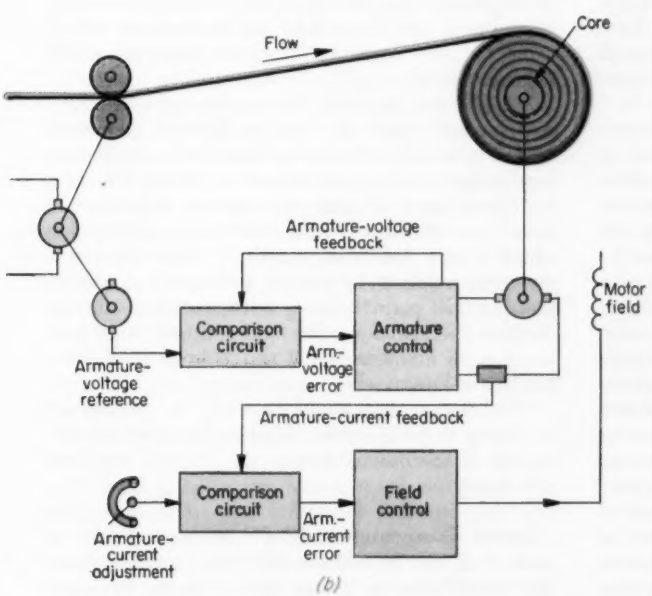
In the past, the most widely used type of indirect tension control has been the horsepower-control method. Although the various systems based on this principle appear superficially to vary widely, the differences result largely from the type of power-system components selected and from the circuitry required to integrate these components into a system. Although tension control through horsepower control is less direct than any of the methods discussed so far, it is quite popular because it is completely electrical and requires no mechanical modifications such as rider roll, dancer roll, or tension-meter mounting. Compared with the rider-roll method, this technique is one step further removed from the actual tension by the amount of electrical losses which must be considered in the constant-horsepower system for comparable accuracy.

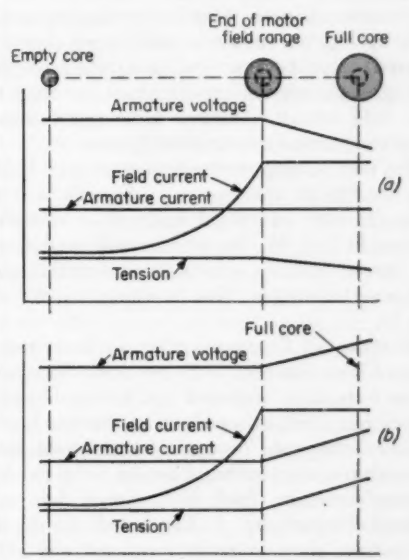
The various constant-horsepower control tension-control methods are all based on the following ideas, neglecting both electrical and mechanical losses and considering only the tension component of windup horsepower. First, windup horsepower required to maintain constant tension is constant over the build-up range for any given web speed. In addition, windup horsepower must be proportional to web speed. To meet these two requirements, motor armature voltage is maintained proportional to web speed and armature current is held constant. Armature current must be constant to maintain a given tension value regardless of line speed or buildup diameter. Tension adjustment is provided by adjusting the level of armature current to be maintained.

The two basic features of the constant-horsepower system are executed electrically in two different ways. The generally preferred arrangement, shown in Fig. 8*a*, operates the armature supply under current control with the current-controlled potentiometer providing the means of tension adjustment. The other component of tension horsepower, armature voltage, is maintained proportional to line speed by controlling the motor back emf. This is done by adjusting the motor-field strength through a regulator which obtains its reference voltage from a web-speed tachometer and its feedback signal from armature voltage.

As the reel builds up a small amount, the reel speed will decrease in proportion to reel-diameter increase, since web speed is being held constant by the lead drive. The result will be a decrease in motor back emf and an associated decrease in armature voltage as the fast-acting armature-current regulator holds current constant. The slower-acting armature-voltage regulator will increase the field strength, causing the back emf to be increased until the armature voltage comes back to the desired constant value. Actually, both regulators act more or less simultaneously to perform their respective functions as the reel continuously builds up.

A second horsepower control method is shown in Fig. 8*b*. Here armature voltage is maintained proportional to line speed by direct control of this voltage through a tachometer-follower armature-voltage-





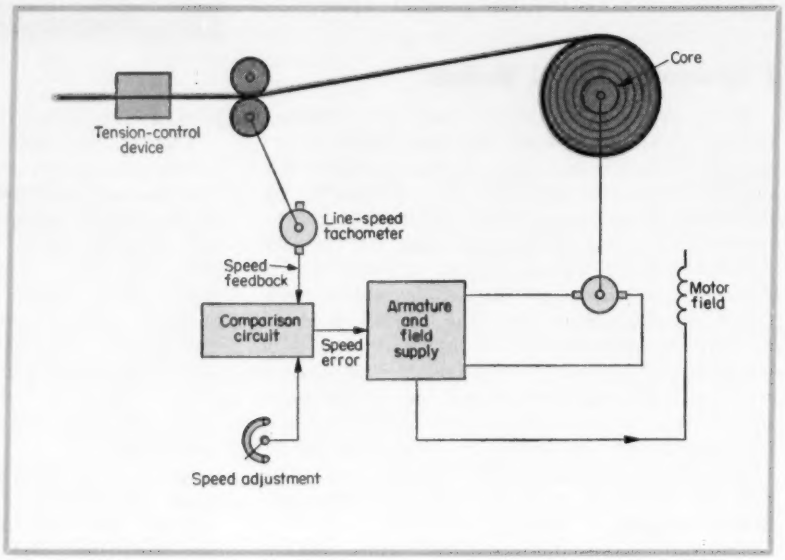


Fig. 9—Center web-winding system in which tension is held in the preceding section by a friction brake, clutch-drag generator, or other means. A line-speed tachometer and a comparison circuit control windup-motor speed.

regulator supply. The effects of changes in back emf on armature current can be seen by:

$$I_a = \frac{E_a - E_b}{R_a}$$

where I_a = armature current; E_a = armature voltage; E_b = back emf; and R_a = armature resistance. Since armature voltage is being held constant by the separate armature voltage circuit, armature current becomes a function of back emf. Armature current is controlled by a current regulator which acts to adjust back emf by controlling field current.

The circuit of Fig. 8*a* is preferred to that of Fig. 8*b* for two reasons. The first is that armature current in Fig. 8*a* circuit is held more closely to the desired value because it is controlled by the fast-acting, armature-voltage circuit rather than through the field circuit. Tension is therefore held more accurately under transient conditions.

For reel buildup somewhat beyond the field range, the tension in the circuit in Fig. 8*a* will tend to drop off with additional buildup—a desirable condition. In Fig. 8*b*, the tension will tend to increase for larger buildup, which is undesirable since the roll may telescope. This is shown in the chart in Fig. 8*b*.

REELING IR COMPENSATION: In these horsepower control arrangements, both mechanical and electrical losses have been neglected and the total input horsepower has been assumed to be tension horsepower. Compensation can be made for electrical losses and somewhat closer control of tension achieved by maintaining armature back emf, rather than armature voltage, proportional to line speed. To do this, the IR voltage drop must be measured and subtracted from the armature voltage. The circuit must be arranged to maintain this net voltage, which is back emf, proportional to line speed. The function thus provided is referred to as "reeling *IR* compensation."

Memory Rheostat-Stall Tension: With either circuit of Fig. 8*a* or *b* the accuracy of tension control decreases with decreasing web speed until at stalled conditions, the accuracy is poor indeed. As a matter of fact, since both are based on the principle of making back emf proportional to web speed, there is *no* control at zero speed, since at that time back emf is zero and will be unaffected by changes in motor-field strength. This means, at zero speed, that the horsepower method of tension control breaks down completely, and if tension is to be maintained at this time, the method of operation must be changed at some point above a minimum operating speed. This is accomplished by modifying the back emf regulating circuit by building a "memory" in the field-adjusting portion of the circuit. This memory makes it possible to hold the field at the correct value for any particular diameter even when the drive is stopped.

Usually the memory is a motor-operated rheostat through which the field is adjusted at normal operating speeds to maintain back emf. The field is kept proportional to reel diameter. When the drive is stopped power is removed from the field-rheostat motor and the field is held constant at the value at which it has just been regulated. This will assure the same value of tension at stall speed as during the prestall period since, with constant current through the armature, the field strength must be a function of diameter alone and is essentially independent of line speed.

This modification could be made in the circuits in Fig. 8*a* or 8*b* by adding a motor-operated potentiometer as the output element of the field regulator and supply.

Inertia Compensation: If the memory rheostat is used, it is easy to add an additional plate or plates for "block" inertia compensation to the armature current circuit. This change will provide the nec-

essary additional torques for acceleration and deceleration so that tension torque can be made more nearly constant during these periods. Required field strength and block forcing are both functions of reel buildup. If the main drive is accelerated by a motor-operated rheostat, the block compensating signal can be added and removed by the same relay function that operates the main speed rheostat.

Where the main drive is accelerated by some other device, the extra plates on the memory rheostat can be used with an RC type inertia-compensation circuit to provide the inertia compensation function.

The main advantage of the constant-horsepower method of tension control is the convenience of the control, since it is completely electrical. Its big disadvantage is that it uses a completely indirect system of sensing, and its accuracy can be no greater than the accuracy of the compensations made for electrical and mechanical losses.

Braking Preceding Section

In all of the systems discussed previously, it has been assumed that web speed was being maintained by the drive ahead of the windup and that the windup was controlled to maintain tension. In the drive in Fig. 9, the windup is designed to hold line speed. Control of tension is accomplished in the preceding section by mechanical means (brake or clutch) or electrically (dc drag generator or ac motor with special characteristics).

The windup drive is a speed-regulated drive having a conventional speed-adjusting reference potentiometer and a speed feedback derived from a dc tachometer mechanically connected to provide a measure of line speed. The amplifier and power-output elements supply armature and field power to the windup motor.

Tension will be maintained as accurately as the type of device used on the preceding drive permits. If a mechanical device is to be used, there will be some random variations depending on the change in friction characteristics of the device. Furthermore, the tension held will vary as some function of web speed. If an electrical device is employed, tension will vary slightly for a given web speed if the friction in the gearing between the electrical device and the tension control point changes in a random manner. The accuracy to which tension will be maintained for different line speeds will depend entirely on the tension-speed characteristics of the device.

Often in a drive of this type, tension is unimportant. For example, the preceding drive may involve an extruding operation where speed control is the primary objective and tension is indeterminate and of no consequence. Another example is a textile beamer drive in which a multitude of individual fibers are involved, each controlled in the preceding section by its own means of tension control.

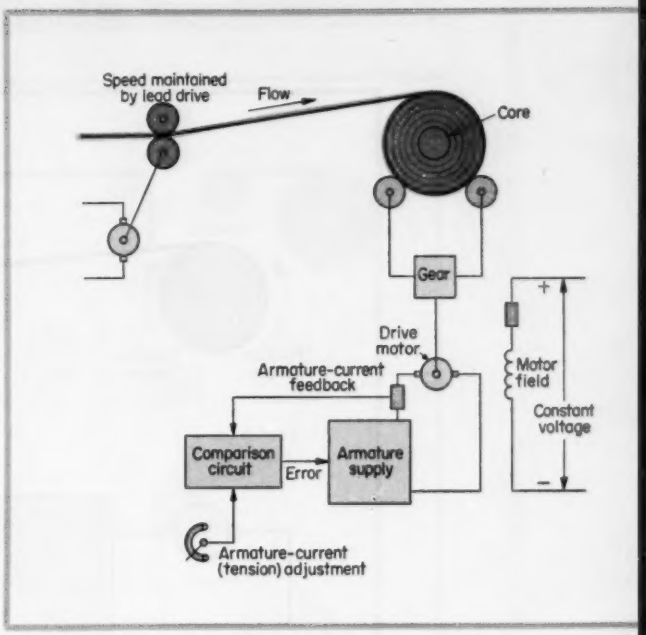


Fig. 10—Surface web-winding system. Tension is regulated indirectly by controlling drive-motor torque.

Surface-Driven Windup System

All drives discussed so far have been center wind. In Fig. 10 is the surface-wind reeling drive in which the reel is driven by rolls in contact with the surface of the windup reel. This system is similar to the horsepower control systems with the important exception that the field strength of the windup drive is not required to change with reel buildup. Control is by armature range only, with the field maintained at a fixed value.

For a given tension, it is only necessary to hold the armature current constant throughout the buildup range. During this period motor speed will remain constant. The potentiometer that provides the armature-current reference signal is therefore the tension adjusting means also.

For a given line speed, the tension will remain substantially constant as the reel builds up, primarily because the electrical and mechanical losses will remain nearly constant. The reason is that the motor speed itself stays constant throughout the buildup range. For a given setting of the tension control, tension maintained will change somewhat with changing web speed unless compensation is made for the changing electrical and mechanical losses. In this instance, since both types of losses are a function of web speed alone and are essentially independent of buildup diameter, the necessary compensation is simpler and more accurate than in the indirect systems for tension control of a center-driven reel.

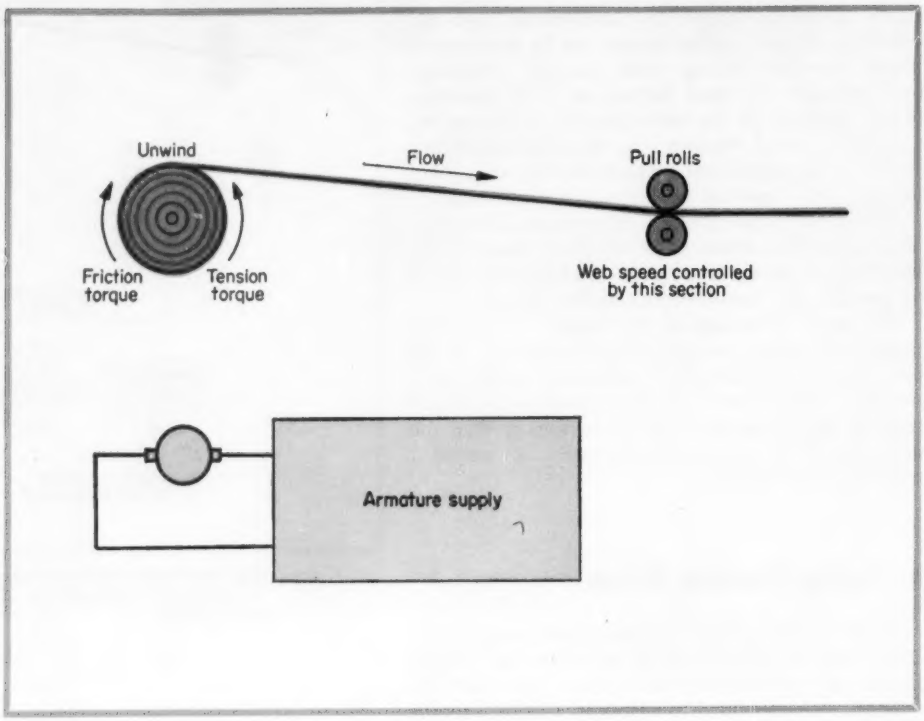


Fig. 11—Basic tension-control system for center-driven unwind drive. The armature supply must be capable of delivering or accepting power.

Center-Driven Unwind System

Each of the systems discussed in this article for tension control of center-wind windup drives has a counterpart in a similar center-driven unwind drive. The only exception is the system which uses friction braking of the lead drive to control tension of the web.

In an unwind drive, Fig. 11, the unwind drive motor must be capable of regenerative braking in most cases. Because of the regeneration design requirement, the armature supply selected for the unwind motor must be capable of either supplying or accepting power. This requirement calls for a dc generator, amplidyne, or a back-to-back electronic armature supply, constant current supply, or other power supply able to accept power.

In all other respects, the unwind drives are very similar to their windup counterparts. The advantages and disadvantages listed for windup tension control by direct or indirect torque control and indirect horsepower control apply to analogous unwind drives.

Center-Driven Rewind System

In certain applications material must be rewound from one center-driven reel to another. Typical operations include inspection, embossing, or slitting as the material passes between reels. Furthermore, in a typical case, there is no intermediate section for establishing line speed. Both line speed and tension are controlled by applying appropriate control to the unwind and rewind drives as a complete system.

One such system in which direct control of both tension and speed is maintained is shown in Fig. 12. In it, the unwind and windup motor armatures are connected in series and powered from a single supply. Armature current is held at a constant rated value, regardless of speed or tension requirements. The power drawn from the line by this supply also overcomes the mechanical and electrical losses for both the unwind and rewind drives.

Line speed is controlled by the left-hand drive in a closed-loop system composed of a manual speed-setting potentiometer, a tachometer driven at web

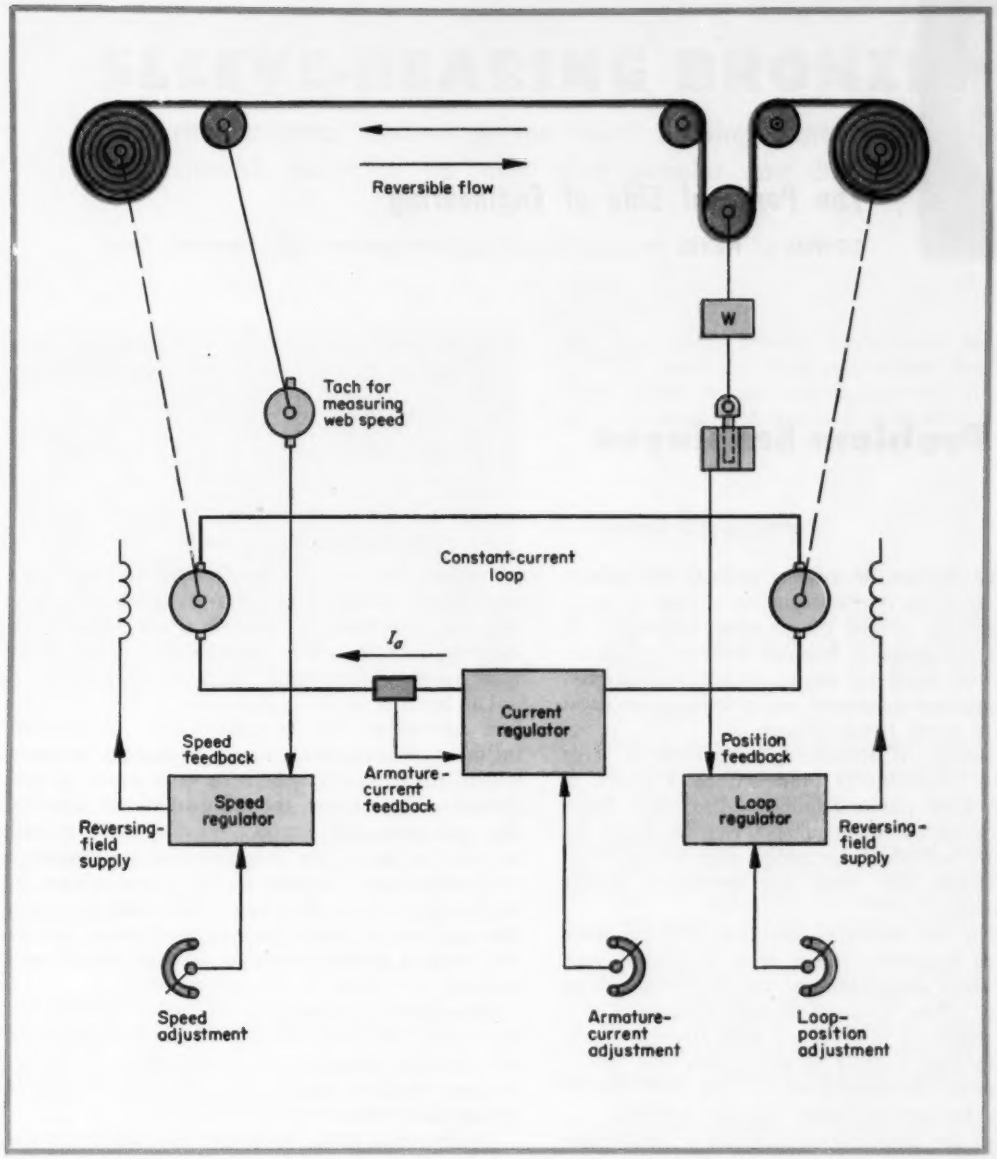


Fig. 12—Reversing rewinder drive. The system uses loop and weight for tension control, and tachometer feedback for web-speed control. Operation is based on a constant armature-current system.

speed for speed feedback, and a reversing field supply. The field supply operates as a function of speed-error voltage to control speed by regulating the field strength of the left-hand motor. Similarly, the right-hand motor maintains the position of the weighted loop through another reversing field supply to control the torque on the right-hand motor.

This system can control web speed in either direction while maintaining control of tension. This feature is useful in inspection applications.

The Personal Side of Engineering

EDWIN C. NEVIS Personnel Research and Development Corp., Cleveland, Ohio

The Problem Employee

OVER the last 20 years a gradual but definite change has developed in the attitude of management toward the problem employee. At one time the practical business attitude toward an "unqualified" employee was to fire him immediately. But today, executives and supervisors go to great lengths to avoid firing a man.

This change in attitude first occurred in large companies, undoubtedly prompted by a desire to maintain good public relations. Also, in a large, varied-activity operation, a spot can be found for almost any individual, no matter what his qualifications. Today, the trend has spread to smaller organizations.

People in the personnel-consulting field are more and more frequently called upon to consult with a client about employees who are not doing well on their jobs. Often, all people in a department or division are evaluated to develop a more effective organization through shifting of individuals and jobs.

Reasons for the development of this trend are not clear-cut, but several factors can be isolated.

Perhaps the most influential factor is the tremendous advancement of humanistic values as a practical business consideration. Business leaders have increasingly become aware of, and have made use of, principles of good human relations.

Another factor: As we have moved into a period of relative shortage of skilled personnel, companies have recognized the need to retain every individual who can contribute to the organization. Having made an investment in a man, management feels that anything which can be done to salvage some aspect of that investment is worthwhile. Too, as management has become more complex, business leaders have learned to indulge in self-analysis—to stand back and evaluate their operation and its effectiveness. With this has come a decided reaction against any inclination to "bury their mistakes."

Management's concern with achieving satisfactory job adjustment for its employees has reached large proportions. Many companies—even though they feel they must sever a man's job relationship—work with the man to obtain more suitable employment with another organization or in another field.

The benefits to the organization of these humanistic approaches can be considerable. In addition to the public-relations value, a positive attitude toward the company is built up on the part of employees. They know that, regardless of whether they are good, fair, or poor on the job, they will be able to discuss the situation and the company will make every attempt to find them a spot in which they can do their best. This often motivates the employee to match the company's investment in him with a determination to develop himself and increase his value to the organization.

Management personnel are also affected. They become more cognizant of the need for thorough study and effective utilization of all individuals in the organization—those who are performing satisfactorily as well as those who are not up to par.

On the other hand, companies can lean over backward in giving the employee a chance to prove himself. There is always the danger that the company will go too long with a man. Some managers, because of their "tendermindedness," find that they can't take strong action with respect to problem employees, even after it has been definitely established that the employee and company are not compatible.

On the whole, however, encouraging results have convinced more and more managers of the value of giving a great deal of thought to the adjustment of employees who have difficulty in performing adequately. Along with this attitude of helping each man to do his best job goes an increasing awareness of several needs: 1. Careful initial selection of employees, so that real problem cases will be few and far between. 2. Continuous, systematic evaluation of an organization and the performance of its personnel.

SLEEVE-BEARING BRONZES

. . . characteristics desired in the ideal bearing metal and specific data for the nine most popular cast bronzes

Technical data and information presented in this article were obtained from members of Cast Bronze Bearing Institute. This article, as part of a planned program of six articles, is taken from the CBBI Design Manual on cast-bronze sleeve bearings. Previous articles from the Manual appeared in September 17 and October 1 issues of MACHINE DESIGN.

SELECTION of a sleeve-bearing material would be no problem if bearing and journal surfaces were absolutely smooth and always separated by a full film of lubricant, if the materials did not experience elastic or thermal distortions, and if the lubricant contained no abrasive particles. Under such ideal conditions, a bearing material of adequate strength becomes the only consideration. However, perfect operation cannot be realized because:

1. The bearing can distort.
2. The shaft can deflect and may rub at the ends of the bearing.
3. Bearing and journal surfaces cannot be made perfectly smooth; consequently, peaks of surface roughness may periodically puncture the lubricant film.
4. The bearing may occasionally be "starved" of lubricant.
5. Lubricant viscosity may be too low.

When these undesirable conditions exist, solid contact is permitted between journal and bearing. It inevitably results in wear and reduced bearing life. Hence, choice of good bearing materials, in conjunction with bearing design and a suitable lubricant, is essential in obtaining trouble-free sleeve bearings.

General Requirements

Experience shows that a good bearing material is:

1. Score resistant.
2. High in compressive strength.
3. High in fatigue strength.
4. Deformable.
5. Corrosion resistant.
6. Low in shear strength.
7. Structurally uniform.
8. Inexpensive.
9. Readily available.

This list of requirements is evidence that selection of a bearing material for a particular application is almost always a compromise. No single material has all of these characteristics in a sufficiently acceptable level. For example, a material having good fatigue strength generally has poor deformability. The order of importance for these general requirements depends upon the particular application.

Score resistance is that quality of a bearing material which prevents damage to the journal during boundary or mixed-film operation or when starting and stopping. Antiweld or antiseizure characteristics are sometimes referred to as score resistance.

Compressive strength, a fundamental requirement, is the ability of the material to carry the imposed load without extrusion or disintegration.

Fatigue strength is the ability of the material to

Table 9—Composition of Cast Bronze Bearing Materials

Alloy	Common Name	Elements (per cent by weight) Copper	Tin	Lead	Zinc	Iron	Nickel	Phosphorus	Aluminum	Silicon	Antimony
SAE 40	Leaded red brass; Ounce metal; Composition metal	84–86	4–6	4–6	4–6	0–0.30	0–1.0	.....	0–0.005	0–0.005	.....
SAE 62	Gun metal	86–89	9–11	0–0.3	1–3	0–0.15	0–1.0	.....	0–0.005	.....	.....
SAE 620	Navy "G"	86–89	7.5–9	0–0.3	3–5	0–0.15	0–1.0	.....	0–0.005	.....	.....
SAE 63	Leaded gun metal	86–89	9–11	1–2.5	0–0.75	0–0.15	0–1.0	0–0.25	0–0.005	.....	.....
SAE 64	Phosphor bronze	78–82	9–11	8–11	0–0.75	0–0.15	0–0.50	0–0.25	0–0.005	0–0.005	0.50
SAE 660	Bronze bearings	81–85	6.25–7.5	6–8	2–4	0–0.20	0–0.50	0–0.15	0–0.005	0–0.005	0.35
SAE 67	Semiplastic bronze	76.5–79.5	5–7	14–18	0–1.5	0–0.40	0–0.75	0–0.05	0–0.005	0–0.005	0.50
AMS 4840	High-leaded tin bronze	67.5–72.5	4.5–6	23–26	0–0.5	0–0.30	.....	0–0.05	.....	.....	0–0.20
ASTM B 148-52-9C	Aluminum bronze	83.0–87.0	....	.....	....	3.00–5.00	0–2.50	.....	10–11.5	.....	(Manganese, 0–0.50)

Table 10—Nominal Physical Properties of Cast Bronze Bearing Materials

Alloy	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation (% in 2 in.)	Reduction of Area (per cent)	Brinell Hardness Number (500 kg load)	Modulus of Elasticity (psi)	Impact Strength, Izod (ft-lb)	Density (lb/cu in.)
SAE 40	35	18	28	25	60	13.5×10^6	6-12	0.318
SAE 62	45	22	25	20	65	12.5	4-16	0.314
SAE 620	40	20	30	25	68	14 0	9-22	0.315
SAE 63	40	20	25	25	70	13	3-11	0.317
SAE 64	35	18	20	10	63	10.5	2-8	0.321
SAE 660	35	20	15	20	60	12.0	4-12	0.316
SAE 67	30	17	15	15	55	9.5	4-6	0.332
AMS 4840	25	15	15	10	48	9.0	3-6	0.326
ASTM B 148-52-9C	90	37	15	15	195	18×10^6	10-15	0.272

give satisfactory service life when subjected to variable stresses.

Deformability is that quality of the material which permits it to yield, if necessary, to deformation under operation without causing failure.

Conformability is desirable when the journal touches the end of the bearing as a result of load deflection in both journal and bearing. The bearing should adjust itself by wearing or wiping away without developing a high-temperature condition.

Embeddability is important when dirt enters the clearance space. If a dirt particle cannot embed itself in a relatively soft bearing material, it will jam itself between a hard bearing material and the shaft and eventually cut a groove in both.

Corrosion resistance is that quality of a material which reduces or eliminates wearing away caused by various acids formed during oxidation and deterioration of lubricants. The danger of bearing corrosion can be greatly reduced by using inhibited oils.

Shear strength is the ability of the material to resist movement of one layer of the material with respect to another layer. Experiments indicate that the most desirable bearing metals have a soft, low-melting constituent in which actual shearing occurs.

Structural uniformity is that quality of the material which results in a sound, nonporous surface necessary to promote and maintain full-film lubrication.

Low cost and **availability** often play a major role in selection of a bearing material, especially if large quantities are involved.

Table 11—Equivalent Government and Society Specifications*

SAE	ASTM	AMS	Navy	Military	Federal	AAR
40	B 62-52 B 145-52-4A	4855B	46-B-23e	MIL-B-16444	QQ-B-691b-2	.....
62	B 22-52-D B 143-52-1A	4845D	.....	.....	.....	.....
620	B 143-52-1B	....	46-M-6i	MIL-B-16576	QQ-B-691b-5	.....
63	.....	....	.....	.....	.....	.....
64	B 144-52-3A	4842A	.....	.....	.....	M-503-48 (Phosphor Bronze)
660	B 144-52-3B	....	46-B-22g-VI	MIL-B-16261-VI	QQ-B-691b-12	.....
67	B 66-52 (Hard Bronze) B 144-52-3D	4825A	46-B-22g-IV	MIL-B-16261-IV	QQ-B-691a-7	M-503-48 (Hard Bronze)
...	B 66-52 (Soft Bronze) B 144-52-3E	4840	46-B-22g-V	MIL-B-16261-V	.....	M-503-48 (Soft Bronze)
...	B 148-52-9C	....	46-B-18d-III	MIL-B-16033-III	QQ-B-671b-3	.....

Key: SAE, Society of Automotive Engineers; ASTM, American Society for Testing Materials; AMS, Aeronautical Material Specifications; Navy, U. S. Navy Department; Military, U. S. Dept. of Defense (MIL); Federal, General Services Administration; AAR, Association of American Railroads.
*In some cases, compositions are similar but not exactly equivalent.

Thermal Coefficient of Expansion (in./in./deg F)	Thermal Conductivity (Btu-ft/hr/sq ft/deg F)	Maximum Operating Temperature (F)	Max Unit-Pressure Load (psi)	Compressive Strength Data: Permanent Set (in.)	Compressive Strength (1000 psi) for Sample Thickness (in.) of . . . 0.125	0.250	0.500	1.000	Alloy
10.9×10^{-6}	48	450	3500	0.001	28	17	14	13	SAE 40
				0.005	42	23	18	16	
10.0	37	500+	4000	0.001	26	23	22	22	SAE 62
				0.005	56	33	28	26	
10.0	45	500	4000+	0.001	28	25	23	21	SAE 620
				0.005	51	37	28	25	
9.9	..	500	4000+	0.001	36	24	22	19	SAE 63
				0.005	57	36	33	32	
10.2	27	450+	4000	0.001	22	19	18	17	SAE 64
				0.005	29	27	23	20	
10.0	27	450+	4000	0.001	30	26	21	18	SAE 660
				0.005	44	32	25	21	
10.7	..	450	3000+	0.001	20	17	14	13	SAE 67
				0.005	35	27	21	16	
10.3	..	400+	3000+	0.001	17	15	13	11	AMS 4840
				0.005	26	22	17	14	
9.0×10^{-6}	32	500+	4500+	0.001	45	30	25	18	ASTM
				0.005	95	48	39	31	B 148-52-9C

▶ Cast Bronze Materials

Bronze offers a favorable compromise with respect to the general requirements for a good bearing material. Cast bronzes, in general, exhibit fair deformability; good score resistance, structural uniformity, shear properties, and compressive strength; excellent fatigue strength and corrosion resistance; and the lowest cost in the field.

Trying to be specific about bronzes is difficult because of the many different compositions and modifications of these compositions. Bronze bushings are suitable for a wide range of applications. They have great strength, yet they can be easily and economically produced in a variety of forms. Even when only one or two bearings are required, the cost is low. "Machined in" bearing tolerances are also an advantage cost-wise in comparison with close-tolerance housings, subassemblies, etc.

Bronze sleeve bearings can be made as a single, solid unit with no bond or liner to fail. Hence, they are extremely reliable. Also, relatively thick walls provide an adequate reserve for wear.

The relatively high thermal conductivity of cast bronze is an advantage in removing heat from bearing surfaces, thus tending to prevent "hot spots" such as may occur in clad-type or steel-backed bearings with only a few thousandths of bronze or babbitt for a bearing surface.

Soft bronze alloys containing large amounts of lead and small amounts of tin have relatively low strength but good frictional characteristics. At the other extreme are high-tin alloys with very little lead. These have high strength and hardness but less-favorable friction characteristics. Intermediate alloys contain various amounts of tin and lead with the addition of small amounts of other elements such as zinc, silicon, phosphorus, nickel, and aluminum. Nine of the most popular cast-bronze bearing materials, their common alloy names, and their chemical composition are listed in Table 9.

Important physical properties of the nine popular cast bronzes are given in Table 10. Heretofore, a cast-bronze bearing material was generally selected for the tensile properties of the alloy. The vast majority of bearings in operation today, however, are in compression only. In the table, compression data are tabulated for a permanent set of 0.001 and 0.005 in. on a 1 sq in. area for thicknesses of 0.125, 0.250, 0.500, and 1.000 in. This information should not only help the designer select the most suitable alloy but also indicate necessary wall thickness for the bearing. Typical tensile properties, also listed in the table, are seen to have no definite relationship to the compression values for the alloys.

Selection of a cast bronze alloy for a bearing requires careful consideration of the important material properties described as deformability and conformability. Alloys with high physical properties are not always the best. Leaded bronzes, although they have lower physical properties, are generally the best bearing alloys.

Specifications for the nine cast bronzes are cross-referenced in Table 11. Important characteristics and typical applications are listed in Table 12.

Tin bronzes, which include SAE 62, SAE 620, and SAE 63, are generally used in those applications which require high loads at low speeds. Because of their hardness, these bronzes require adequate and reliable lubrication and will tolerate very little misalignment.

Table 12—Characteristics and Uses

SAE 40

(85 Cu, 5 Sn, 5 Pb, 5 Zn)

Characteristics: Reasonable strength; excellent thermal conductivity; sound material structure; reasonable corrosion resistance to sea water and brine; good machining and casting properties—sand casting of sections larger than 1-in. thick is not recommended.

Uses: Light loads and low to medium speeds; primarily for bearing shells and backing for babbitt-lined bearings; cornpicker snapping roll bushings; deep-well pump line-shaft bearings; automotive-transmission thrust washers; low-pressure valve bearings; manifold bushings for earth-moving machinery; pump sleeves; propeller bushings; spring bushings for farm and automotive equipment.

SAE 62

(88 Cu, 10 Sn, 2 Zn)

Characteristics: Hard; strong; good corrosion resistance, especially to sea water; wear resistant; high resistance to pounding; difficult to broach but can be bored or reamed; requires good, reliable lubrication and a shaft hardness of 300-400 Bhn.

Uses: Heavy loads and low speeds; piston-pin bushings; valve guides; rolling-mill bearings; rocker-shaft bushings for internal-combustion engines; worm bearings, pilot bearings, roll bushings, and linkage bushings for machine tools.

SAE 620

(88 Cu, 8 Sn, 4 Zn)

Characteristics: Hard; strong; ductile; corrosion resistant to sea water and brine; wear resistant; good resistance to pounding; good machining properties—similar to SAE 62 but easier to work in foundry; requires reliable lubrication, good alignment, and a shaft hardness of 300 to 400 Bhn.

Uses: Heavy loads and low speeds; bushings for aircraft landing gear; bridge bearings; machine-tool bearings; trunnion bearings; trolley wheels; wrist-pin bushings for air compressors.

SAE 63

88 Cu, 10 Sn, 2 Pb)

Characteristics: Hard; strong; good corrosion resistance; wear resistant; good machining and fair casting properties; requires good lubrication and a shaft hardness of 300 to 400 Bhn.

Uses: Heavy loads, low speeds, and severe working conditions; applications requiring strength in addition to bearing properties; bearings for earth-moving machines; locomotive bearings; trunnion bearings; gear bushings and connecting rods for farm equipment; mechanical linkage for farm equipment and packaging machinery; automotive spindle bushings.

SAE 64

(80 Cu, 10 Sn, 10 Pb)

Characteristics: Good strength; low thermal conductivity compared to high-tin bronzes; generally high physical properties combined with fairly good bearing qualities; corrosion resistant to mild acids as found in mine water, good resistance to mineral waters or paper-mill sulfite liquor; excellent wear resistance under conditions of high speed, heavy pressure, shock, and vibration; low friction; good machining and fair casting properties; can be used where lubrication is doubtful; requires hardened shaft; maximum shaft surface speed can be 800 to 1000 fpm.

Uses: Heavy loads and high speeds; backing for babbitt-lined bearings; wrist-pin and valve rocker-arm bushings; fuel and water-pump bushings; aircraft control bushings; electric-motor bushings; steering-knuckle bushings; track-roller bushings; crankshaft bearings for outboard motors, power lawn mowers, and garden tractors; gear bushings for farm equipment reducers, and motorcycles; cam bushings for mechanical devices; farm equipment, and diesel engines; crankshaft, spindle, and connecting-rod bushings for farm equipment; piston pins for packaging equipment and diesel engines; linkage bushings for presses; roll-neck bearings; lathe bearings; babbitt-lined armature bearings for electrical locomotives; railroad-car bearings; rolling-mill bearings; trunnion bearings.

SAE 660

(83 Cu, 7 Sn, 7 Pb, 3 Zn)

Characteristics: Good hardness, strength, and wear resistance; excellent antifrictional qualities; good casting and excellent machining properties; can be readily broached or reamed.

Uses: Currently the standard cast-bronze bearing material; general utility applications for medium loads and speeds; electric-motor bushings; spring-shackle bushings; torque-tube bushings; bushings for automotive generators, distributors, and starters; motorcycle-engine bearings; sleeve bushings for cranes and draglines; track-roller bushings for crawler tractors; guide bushings for valves, rams, and piston rods; camshaft bushings for tractor engines; roller bushings for conveyors; main bearings for presses; mechanical-linkage bushings for farm and material-handling equipment; spindle bushings for farm equipment and trucks.

SAE 67

(78 Cu, 6 Sn, 16 Pb)

Characteristics: Fair strength; corrosion resistant to sea water and brine, resistant to certain concentrations of sulfuric acid and acids in mine waters; fair wear resistance; excellent antifrictional qualities; nonseizing; good machining and casting properties; can be used where lubrication is doubtful.

Uses: General-service bearing material for moderate pressures and high speeds; general-purpose wearing material for rod bushings, freight and streetcar bearings, and backs for lined bearings; bushings for gasoline pumps; hydraulic glands; seals; deep-well pump-bowl bushings; general bearings for locomotive tenders and passenger and freight cars; rolling-mill bearings; brass and copper rolling-mill neck bearings; gas-engine bearings; diesel-engine bearings; kingpin bushings for earth-moving machinery; drum bushings for cranes and earth-moving machinery; bearings and spacer bushings for pumps.

AMS 4840

(70 Cu, 5 Sn, 25 Pb)

Characteristics: Fair strength; fair wear resistance; low pounding resistance; excellent antifrictional qualities; good conformability—will not score soft shafts; good machining and fair casting properties—requires care in broaching; can operate at high speeds under adverse lubrication conditions.

Uses: Light to moderate loads and high speeds; unsuitable for extremely heavy compressive and shock loads; suitable for bearing liners required to deform locally to conform to irregularities of motion or bad fit; under-water service; water-lubricated bushings; aircraft-carburetor bearings; fire-pump bushings; railroad-car bearings; used extensively for locomotive bearing parts; rod bushings and main bearings for refrigeration compressors; hydraulic pump bushings.

ASTM B 148-52-9C

(86 Cu, 3.5 Fe, 10.5 Al)

Characteristics: Very hard; abrasion resistant; excellent strength; physical properties remain good at elevated temperatures—compressive strength at 500 F is the same as for tin bronzes at room temperature; wear resistant; excellent resistance to repeated, severe impacts; relatively poor antiseizure properties; relatively poor conformability and embeddability; difficult to broach; requires reliable full-film lubrication to prevent metal-to-metal contact and possible scoring; requires shaft hardness of 550 to 600 Bhn to prevent damage to shaft; requires surface finish of 15 to 20 microinches rms on both bearing and shaft.

Uses: Bushings for power shovels and heavy earth-moving equipment; roll-neck bearings; guide-post bushings; turntable bushings; boring-bar guide bushings; machine-tool bearings.

Leaded bronzes, which include SAE 40, SAE 64, SAE 660, SAE 67 and AMS 4840, are ordinarily used for applications requiring intermediate loads at relatively high speeds. Bearing properties of leaded bronzes are enhanced by the additional lead content which fulfills the requirement that a good bearing material contain a soft, low-melting constituent. SAE 67 and AMS 4840 are high-leaded bronzes which handle intermediate loads at slow to relatively high speeds. Their excellent conformability enables them to correct minor misalignment, and their high lead content offers excellent shaft protection in case the lubricant supply should momentarily fail. Physical properties of SAE 64 and SAE 660, the two most widely used bronzes, offer the best compromise to all requirements. They are particularly suited for medium loads at medium to relatively high speeds. As a substitute for the other leaded bronzes, SAE 40 presents certain advantages. In addition to its ability to do a good job at the lighter loads, it is also somewhat lower in cost than the other bronzes.

Aluminum bronze, ASTM B 148-52-9C, is not a "true" bearing material because it lacks some of the common bearing characteristics such as antiseizure, embeddability, and conformability. Main advantages are high strength and retention of favorable characteristics at temperatures in excess of 500 F.

Next article in this integrated program discusses grooving of cast-bronze sleeve bearings. Function of grooves is explained, types are illustrated, proper location in low-pressure region is analyzed, and dimensions are recommended.

Half-Frequency Whirl Speed

In "Bronze Sleeve Bearings," Page 194, September 17 issue, multiplication factor in Equation 15 should be 10^3 instead of 10^{-3}.

Selection of Precipitation-Hardening Stainless Steels

M. E. HOLMBERG
Metallurgical Consultant
Houston, Texas

HIGH-STRENGTH precipitation-hardening stainless steels are the latest development in the evolution of the stainless - steel family. Austenitic chrome-nickel steels have good corrosion resistance, and hardenable chrome steels have high strength. The precipitation-hardening stainless steels have both these properties. They are particularly suitable for services requiring high strength at normal and elevated temperatures and excellent resistance to a wide variety of corrodents.

Steels in the precipitation-hardening series are essentially chromium-nickel stainless steels of carefully proportioned composition. Upon cooling to atmospheric temperatures alloys are in supersaturated solid solution, relatively soft and ductile. By heating to relatively low temperatures, in the order of 850 to 1200 F, the alloys can be precipitation-hardened.

Of course, no single alloy of any metals is the panacea for all problems, and this also applies to the precipitation-hardening alloys. However, the precipitation-hardening stainless steel 17-4 PH seems to offer the best combination of properties for many conditions.

Armco 17-4 PH is a chrome-nickel-copper alloy of iron base. It is supplied from the mill either annealed or hardened to various levels in many shapes and sizes of bar and wire. It is also available in forging billets and remelt stock. Also, many foundries have been licensed to produce the material in castings.

Table 1 shows the typical mechanical properties for various conditions of heat treatment. Note the high strengths to which the material can be treated and the variations of toughness that are available by varying the heat treatment. Temperatures may vary from 850 to 1150 F on this alloy, and it is hardest and strongest in condition H-900. Heat-treatment time varies for different size sections, but usually 1 to 4 hr soak at temperature is required for complete hardening.

Because the hardening is performed at low temperatures it is evident that little, if any, distortion will take place. A small predictable dimensional contraction, 0.0004 to 0.0006 in. per in., takes place during hardening. Also, the low temperature heat treatment does not raise an objectionable scale. Additional machining and straightening after heat treatment is not required.

Comparatively, 17-4 PH has excellent high-temperature strength as shown by Table 2. The high percentage of original strength retained through 800 F makes this alloy of importance in studs and bolting, and in high-temperature valves, fans, and compressors, *Fig.* 1.

An important factor in the selection of proper heat treatment is the

Table 1—Mechanical Properties of Alloy 17-4 PH for Certain Heat Treatments

Condition Code	A	H-900	H-925	H-1025	H-1075	H-1150
Heat Treatment All solution treated	Solution Treated at 1900 F, ½ hr. Oil Quench	Hardened at 900 F, 1 hr. Air Cooled	Hardened at 925 F, 4 hr. Air Cooled	Hardened at 1025 F, 4 hr. Air Cooled	Hardened at 1075 F, 4 hr. Air Cooled	Hardened at 1150 F, 4 hr. Air Cooled
Ultimate Strength (psi)						
Tension	150,000	200,000	190,000	170,000	165,000	145,000
Yield Strength, 0.2 Per Cent Offset (psi)						
Tension	110,000	185,000	175,000	165,000	150,000	125,000
Compression	110,000	178,000	.....	.....	.....	.....
Endurance Strength (psi)						
10 million cycles	.....	90,000	.....	.....	.....	.....
100 million cycles	.....	80,000	.....	.....	.....	.....
Elongation in 2 in. (per cent)	6 to 15	14	14	15	16	19
Reduction of Area (per cent)	30 to 60	50	54	56	58	60
Charpy V-Notch Impact (ft-lb)	.....	20	25	35	40	50
Hardness						
Rockwell C	.....	44	42	38	36	33
Brinell	.....	420	409	352	341	311
Modulus of Elasticity						
Tension (million psi)	.....	28.5	.....	.....	.....	.....
Torsion (million psi)	.....	10.5	.....	.....	.....	.....

Table 2—Short-Time High-Temperature Tensile Properties

Temperature (F)	70	600	700	800	900	1000
Ultimate Tensile Stress (1000 psi):						
17-4 PH	145	124	120	116	109	96
Monel	90	74	70	65	55	48
410	114	100	95	91	83	74
4140	132	...	113	104	91	75
Offset Yield Strength, 0.2 Per Cent (1000 psi):						
17-4 PH	125	120	114	112	104	93
Monel	50	30	29	28	23	22
410	88	81	78	75	68	63
4140	117	...	88	85	77	58

Conditions:
17-4 PH—Condition H-1150
Monel—Hot rolled bar
410—Quenched and tempered
4140—Oil quenched at 1615 F, tempered at 1100 F

Table 3—Corrosion Rates and Mechanical Properties
Before and after exposure in flowing sea water

Material	Exposure (years)	Corrosion Rate (in. per yr)	Ultimate Ten. Str. (1000 psi)	Elong. in 2 in. (per cent)	Reduct. of Area (per cent)
17-4 PH Condition H-900	Original	....	206.0	11.5	45.5
	6	0.001	192.7	13.5	52.2
410 Hardened Tempered	Original	....	112.1	22	67
	6	0.003	112.0	25	69
Monel	Original	....	110.8	22	66
	7	0.001	110.2	18.9	60.3

galling and seizing characteristics of materials at various hardness levels. Alloy 17-4 PH has good resistance to seizing against itself when a differential of hardness exists.

Corrosion resistance is always important in selecting materials. Even though the precipitation-hardening stainless steels are new, extensive testing has developed a large amount of information concerning their suitability in corrosive environments. Table 3 shows corrosion rates and mechanical properties before and after exposure in flowing sea water. While these data are shown for condition H-900, it is known that condition H-1100 also exhibits excellent corrosion resistance, thus offering a wide range of toughness and strength in brine conditions. The corrosion resistance of 17-4 PH to brines makes this alloy ideal for sea-water pumps and valves, water-flooding operations, and for chemical operations involving brines.

Resistance to stress-cracking or hydrogen embrittlement is important when using high-strength metals. This is true whether or not the metal is classified as corrosion resistant. There are numerous services in which significant evidence of corrosion does not occur. However, the slight corrosion, which may not even be apparent, results in hydrogen being formed at the metal surface. If this hydrogen diffuses into the metal, it makes high-strength alloys susceptible to brittle failure.

Tests show high resistance to stress-cracking or hydrogen embrittlement of 17-4 PH, condition H-1050 to H-1150, Table 4. Fully hardened 17-4 PH, condition H-900, is susceptible to breakage. However, the material in condition H-1050 to H-1150 withstands stresses up to about 70 per cent of the tensile yield strength. In another series of tests, condition H-1150 material successfully passed 20 hr in an acidulated arsenous-oxide solution at a current density of 2 amp per sq in.

Machining can be done in either the annealed or hardened condition. One of the greatest advantages of the alloy is that final dimensions can be turned without allowance for scaling or distortion. In large sections, the predictable contraction can be determined and allowed for in machining. Condition A or condition H-1150 can be machined at about the same rate as Type 410 Bhn 280-320. In the hardened conditions, it should be machined at about 60 per cent of the rate for condition A. Cold-sawing for cutting bars and billets should be used since

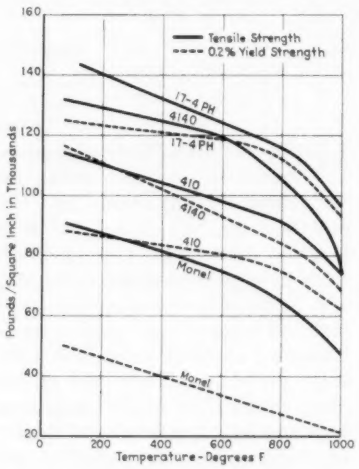


Fig. 1—Typical short-time, high-temperature properties of stainless alloys.

Table 4—Tension Tests at Certain Stress Levels
In ½ Per Cent Acetic Acid Saturated with Hydrogen Sulfide

Grade	Composition (per cent) Carbon	Chromium	Others	Treatment (Heat; Quench; Temper)	Rockwell Hardness (C scale)	Ultimate Ten. Str. (1000 psi)	0.2 Per Cent Yield Str. (1000 psi)	Elong. (per cent)	Reduct. of Area (per cent)	Applied Stress (1000 psi)	Time to Failure (hr) (low-avg-high)
410	0.101	12.35	0.50 Mo	1800 F; 600 F, air; 600 F, 4 hr, air.	40	197.7	168.1	15	62	100	2-98-136
										90	2-43-153
										80	23-69-136
										70	97-220-1500*
										60	1500*-1459*
										50	868-1081*-1294
410	0.096	12.65	0.14 Mo	1800 F; 600 F, air; 1010 F, 4 hr, air.	32	146.8	137.0	18	69	100	115-123-126
17-4 PH	0.034	16.32	4.62 Ni, 3.12 Cu	1900 F; 600 F, air; 1150 F, 4 hr, air.	32	148.6	139.0	15	63	110	-106-1050*
										100	556-1002*-1078*
										90	1040-1040*-1010*
9 Per Cent Nickel	0.15	....	8.43 Ni	As received.	30	149.3	138.2	24	66	100	-3-4
										50	-24-57
4340	0.39	1.06	1.89 Ni, 0.22 Mo	1500 F; 350 F, air; 1070 F, 1 hr, air.	34	156.7	150.5	19	32	100	-2-13

*Indicates test stopped without failure of sample.

New line of precision sub-miniature DC motors with optional speed governors and gear trains

The new Cramer Type 810 sub-miniature DC motors have been perfected to meet the growing need for a unit combining very light weight with high efficiency and accurate speed control, in a standard ⅞" cylindrical frame. These motors are available with or without speed governors and gear trains, offering the user an exceptionally wide choice to meet most application needs.

Operation

Type 810 motors, without the addition of a speed governor, have a nearly linear relationship of speed to applied voltage, and of speed to load or torque. Precise control of armature winding permits an unlimited selection of operating characteristics in terms of these three basic factors. In the ungoverned versions, accurate speed control can easily be obtained by varying the applied voltage below the rated maximum. Efficiency remains high over virtually the entire operating range.

Speed Governors

These are of the internal, vibrating-reed type, regulating motor speed on the basis of average power supplied to the armature circuit, and require no separate brushes and no external arc-suppression network. The effective degree of speed regulation will depend on several factors in each instance. In general, however, under a combination of load and voltage variation the speed will not vary more than ±2% with a ±20% voltage change and a ±50% load change from nominal. The speed at which the unit regulates is set accurately at the factory, to meet the user's specified requirements.

Gear Trains

The addition of a gear train provides a wide range of output shaft speed reductions, with a corresponding increase of available output torque to a maximum continuous load of 50 ounce-inches. Seventy-three different gear ratios are available, from 48:1 to 13,000:1.

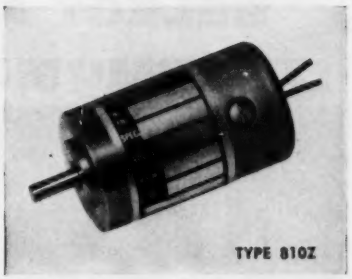
Features

OPERATING VOLTAGE — any specified DC voltage from 3 to 30 volts. Armature is wound for the specified voltage, load and speed.

OUTPUT SPEEDS — no-load speeds from 5,000 to 20,000 rpm, with different armature windings as required by the application.

SPEED REGULATION (governed) — ±2% for ±20% voltage change and ±50% load change from nominal.

ARMATURE — precision ground, Mylar insulated, lacquered and baked.



TYPE 810Z

COMMUTATOR — molded type, ground and polished.

BRUSHES — cartridge type for easy replacement, with springs soldered to brushes and holders to insure positive electrical connection.

MAGNET — Alnico VI, with machined pole pieces.

BEARINGS — precision ball bearings, life lubricated to meet the specific requirements of the application.

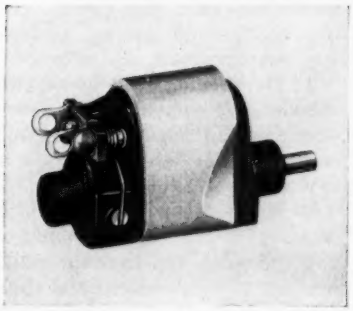
SHAFT — type 416 stainless steel.

GEAR TRAINS — precision-cut 120 pitch, integrally hobbed with pinions to minimize eccentricity.

HOUSINGS — anodized aluminum.

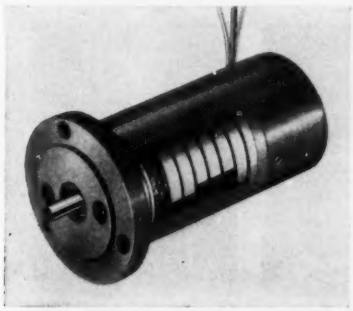
WEIGHTS — from 2.1 oz. to 4.7 oz., depending on choice of speed governor and gear trains.

THREE OTHER BASIC DC MOTORS OF BROAD USEFULNESS



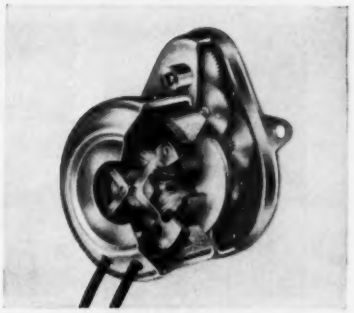
OPEN-FRAME MINIATURE **TYPE 820**

Type 820 resembles Type 810 (above) in its basic operating characteristics, and is even smaller in size and lighter in weight. Available only in standard form, without speed governor or gear train, it operates on any specified DC voltage from 3 to 30 volts. No-load output speeds range from 5,000 to 30,000 rpm, depending on armature winding. Special magnet design permits an extremely light weight of only 1.4 oz. DETAILS IN BULLETIN PB-820.



1 3/16" CYLINDRICAL **TYPE 830**

Type 830 is a slightly larger version of the basic ⅞" motor (Type 810), permitting larger load capacity at equivalent speeds, and is offered with or without speed governors. Armatures are wound for any specified voltage from 3 to 30 volts DC. No-load output speeds range from 5,000 to 20,000 rpm, depending on winding. Weights of ungoverned motor, approx. 8 oz.; governed, about 8.25 oz. Alternate mounting arrangements are available. DETAILS IN BULLETIN PB-830.



ELLIPTICAL GEAR TRAIN **TYPE 800**

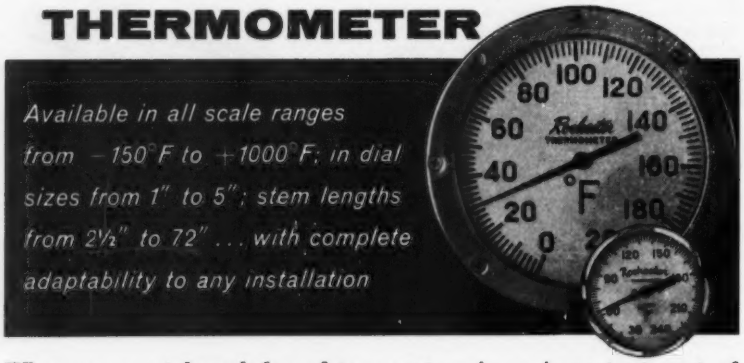
Offering an unusually wide range of output speeds, with high torque, low current drain, and excellent speed characteristics. Output speeds from 2 rpd to 900 rpm, with torque as high as 30 oz-in. Operating voltage may be any specified value from 3 to 30v DC. Type 800 is also available without gear train, for output speeds from 960 to 3,000 rpm. Speed regulation is within ±10%, current drain as low as 30 ma. DETAILS IN BULLETIN PB-800.

CRAMER CONTROLS

CORPORATION

Box 6, Centerbrook, Connecticut

Whenever temperature and performance must go hand in hand SELECT AN RMC THERMOMETER



Wherever exact knowledge of temperature is an important part of function, you will discover that there are a lot of good reasons for selecting RMC thermometers.

Suppose for instance that you are designing equipment for low temperature work. You know that an RMC thermometer is hermetically *dry-air* sealed so that no ice coating can ever form on the bimetallic element to stop readings at below freezing temperatures. You can *always* be sure of your low temperature readings.

If severe vibration is a factor, the extra damping of RMC thermometers goes to work to make reading easier, more accurate and to prevent fatigue of the registering element. And when necessary, it can always be easily re-calibrated without opening it or destroying its essential accuracy.

No moisture to freeze the element or fog the dial. RMC thermometers are hermetically *dry-air* sealed then immersion tested for 15 minutes.

No "over" or "under" readings. Re-calibration for extreme accuracy in any range, or necessitated by severe shock, can be done in seconds without breaking seal.

Permanent accuracy with freedom from vibration-caused variable is built in. Silicone damping and special damping bearing minimize vibration and keep shaft alignment true.

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hot-sawing or abrasive-wheel cutting may crack the steel.

In welding 17-4 PH, any of the standard welding methods, except carbon arc, may be used. One of the outstanding attributes of this steel is its ability to withstand welding operations without preheating.

ASME paper 59-PET-17, Petroleum Mechanical Engineering Conference, Houston, Texas, 1959, 8 pages.

management

What It Takes To Manage Advanced-Technology Projects

Paul O. Gaddis
Westinghouse Electric Corp.

Requirements for the manager of an advanced - technology project. The increasing complexity of modern technology and the increasingly common necessity of working at the frontiers of scientific knowledge have resulted in a new type of project —the so-called advanced technology project. With this has come the need for a new type of manager. His qualifications can be generalized as:

1. The project manager must be bred in the advanced-technology environment, so that he understands the pace, the people, and the relationships among contractors, subcontractors, and clients.

2. He should have a working knowledge of many fields of science, which he can augment when necessary to delve into the intricacies of a specific technology.

3. He must have a good understanding of industrial administration and sales, and have the qualifications of temperament and character that qualify a man generally for industrial management. He must understand the effects of policy as evolved in large organizations, since he will be working with industrial and governmental groups of large size and considerable power. He must understand profitability in the new and sometimes strange aspects it has assumed since World War II in the advanced-technology industries. This involves a thorough knowledge of the contractual mechanisms used to accomplish advanced - technology work.

4. He must have the requisite faith and stability to carry him through the periods of blind flying when there is no feedback indicating the performance of his group nor of the products they are developing.

5. He must know the functions of each corporate staff specialty, and its relationship to his project. Generally, he must alleviate the pronounced lack of understanding that his technological personnel will exhibit toward these staff groups.

6. The project manager must always remember that training is one of his basic responsibilities. In advanced-technology work, with its emphasis upon schedule and work output, the teaching aspects of management can be unduly subordinated. Under the concept of training responsibility, the manager must continually consider the preparation of first-line technical supervisors for further advancement into administrative roles.

From "Westinghouse Engineer," July, 1959, pp. 102 to 106.

mechanical

Design Curves for Journal Bearings

D. F. Hays, General Motors Corp.

A series of design curves for a full journal bearing of finite length. Curves illustrate the variation of minimum film height with load variable and the variation of coefficient of friction with the Sommerfeld number. The film is assumed to be continuous and the fluid incompressible. A series of illustrative examples is included.

ASME paper 59-MD-11, Design Engineering Conference, Philadelphia, May, 1959; 9 pp.

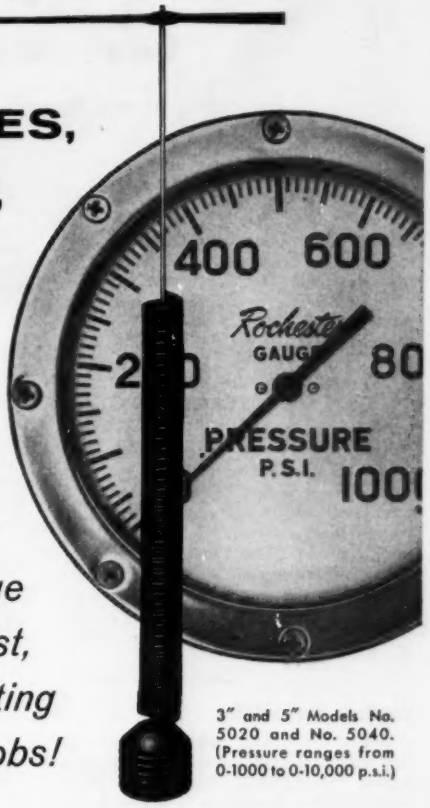
TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organization:

Westinghouse Engineer, P.O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cent to members, 80

Revolutionary New ROCHESTER HIGH PRESSURE GAUGE has pointer connected directly to pressure element

NO LINKAGES, NO PIVOTS, NO GEARS to wear, waver or lag



This is the gauge for your toughest, your most exacting high pressure jobs!

3" and 5" Models No. 5020 and No. 5040. (Pressure ranges from 0-1000 to 0-10,000 p.s.i.)

Now you can practically eliminate maintenance, replacement, and gauge failures—even under the most severe of high pressure service conditions. The new RMC Gauge, models 5020 and 5040, actually approaches the reliability and dependability of the fittings and valves used in pressure equipment.

It is the first pressure gauge to have the pointer directly connected to the pressure element, without linkage or pivots, and with no gears or hair springs.

The pressure element is a multiple turn bourdon coil, to which the pointer is permanentiy attached at one end. As pressure increases, the end of the coil rotates, moving the pointer with it.

The bourdon coil is made from small diameter tubing. Therefore, the pressure forces against the coil are reduced; the mechanical stress on the coil is less; and spring life, cycling life, overpressure, and endurance are all vastly higher than the conventional "C" type bourdon tube gauge.

For safety, long cycling life and continued accuracy under extreme conditions of overload pressures, high vibration, shock and line pulsation, the new RMC High Pressure Gauge is the one complete answer. Available in pressure ranges from 0-1000 to 0-10,000 p.s.i.; dial diameters 1½", 2", 3" and 5". (1½" and 2" models are eccentric pivot-drive types.)

Write, wire or phone for complete information.

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Amplifier & Power Supply

Both the electronic servo amplifier and power supply described in Data Sheet EE-1005 have a keyed plug-in connector to simplify servicing. Amplifier operates from low level ac signals and controls two-phase ac servo motors with output ratings up to 10 w. Specifications are presented. 2 pages. Seneca Falls Machine Co., Electronics Div., Seneca Falls, N. Y. N

Circle 551 on Page 19

Machine Tool Controls

Bulletin SB-1 on True-Trace machine tool controls covers continuous and intermittent positioning systems, hydraulic tracers, numerical controls, and programming consoles. The True-Trace template tracer controls permit duplication of any metal, wood, or plaster pattern to produce one piece, or a long production run. 20 pages. True-Trace Sales Corp., 9830 E. Rush St., El Monte, Calif. K

Circle 552 on Page 19

Electric Terminals

Folder shows user how to choose the best electrical terminal for his particular wiring applications. Choice of basic terminals and connectors is shown, ranging from ring and standard tongue designs through multiple-wire connectors and quick-disconnects. Insulated and non-insulated barrel styles are available. 4 pages. ETC Inc., 990 E. 67th St. Cleveland 3, Ohio. G

Circle 553 on Page 19

Actuators & Computer

Product Data Bulletins 102-11, 105-4, 111-11, and 115-12 respectively describe the Series 320 linear actuator, Series 831C and 835A handcranks, Series 3079 servo actuator and Model 5011 advanced heading computer system. 2 pages each. Lear, Inc., Electromechanical Div., 110 Ionia Avenue, N. W., Grand Rapids 2, Mich. T

Circle 554 on Page 19

Cold Heading Wire

Describing applications and advantages of extruded cold heading wire (cartridge brass, 70 per cent), bulletin also lists available stock tempers, and gives characteristics of the material and specifications. Wire is hot extruded from continuous cast billets and finally cold drawn. 4 pages. Scovill Mfg. Co., Mills Div., 99 Mill St., Waterbury 20, Conn. B

Circle 555 on Page 19

Light Ball Bearings

Hoover 3L00 extra light ball bearings are designed with outer diameter and width dimensions smaller than standard light, medium, or heavy bearings of equal bore size. Sizes, tolerances, and load ratings are presented with illustrations of available designs in Bulletin 108. 4 pages. Hoover Ball & Bearing Co., Ann Arbor, Mich. T

Circle 556 on Page 19

Spiroid Gears

Engineering manual "Lower Cost Design Begins with Spiroid Gears" contains information to assist design engineers in determining basic design requirements such as ratings, selections, center distances, bearing loads, and mounting methods. Illustrated are principle and application of spiroid gears. 36 pages. Illinois Tool Works, Spiroid Div., 2501 N. Keeler Ave., Chicago 39, Ill. J

Circle 557 on Page 19

Meter Relay

The CRMR continuous reading meter-relay shows signal level even while control circuits are energized. Bulletin S-2 entitled "The Picture Story of the CRMR" shows successive circuit stages involved in operation of the new design. 4 pages. Assembly Products, Inc., 75 Wilson Mills Rd., Chesterland, Ohio. G

Circle 558 on Page 19

Pressure Vacuum Controls

Type J27 (uncalibrated) and type H27 (calibrated) pressure-vacuum controls were developed for low cost, highly sensitive instruments. Several models are available within range limits of 30 in. Hg vacuum and 15 psi. Data Sheets 51 and 52 describe these controls. 2 pages each. United Electric Controls Co., 85 School St., Watertown 72, Mass. B

Circle 559 on Page 19

Air Filters

One of a series of application bulletins prepared for engineers, Bulletin 234-P1 covers American air filters in steel mills. It emphasizes filters used in protecting the turbo-blower at the blast furnace, keeping electrical equipment clean at the rolling mill, and providing clean air for comfort. 16 pages. American Air Filter Co., 215 Central Ave., Louisville 8, Ky. G

Circle 560 on Page 19

Electronic Tracer

Pencil line sketches of intricate shapes can be used to guide oxygen shape-cutting machine with the Photocell tracer described in Form F-1287. Booklet shows how built-in automatic kerf compensator makes it possible to reproduce one or thousands of complicated metal parts from exact size drawings. 4 pages. Linde Co., Room 2840, 420 Lexington Ave., New York 17, N. Y. C

Circle 561 on Page 19

Insulating Tubings

Irvington PTFE No. 4201 insulating tubings can be used in −90 to 250° C range for high frequency, low loss applications. Dimensions and prices given in Folder 1181 cover super-thin, thin wall, and ASTM wall tubing. 4 pages. Minnesota Mining & Mfg. Co., Irvington Div., St. Paul 6, Minn. J

Circle 562 on Page 19

Variable Speed Pulleys

Revised Bulletin 4101 covers MS variable-speed pulleys designed to eliminate freezing and sticking. Technical data cover sheaves for ratings of 2, 3, 5, 10, and 15 hp. 12 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 563 on Page 19

Special Shaped Wire

Serving as a handy reference guide, Technical Bulletin T-2 lists properties, advantages, and some applications for special shaped alloy wire. Bulletin is concerned primarily with nickel alloys and stainless steels. 4 pages. H. K. Porter Co., Riverside-Alloy Metal Div., Riverside, N. J. D

Circle 564 on Page 19

Synchronous Motors

Instant starting, reversing, and stopping are characteristics of the Slo-Syn synchronous motors described in Bulletin SS459. Units can be used as direct-current stepping motors, have 72-rpm shaft speed without gears, and start at full 150 oz-in. torque. 12 pages. Superior Electric Co., Bristol, Conn. B

Circle 565 on Page 19

Lubricant Dispenser

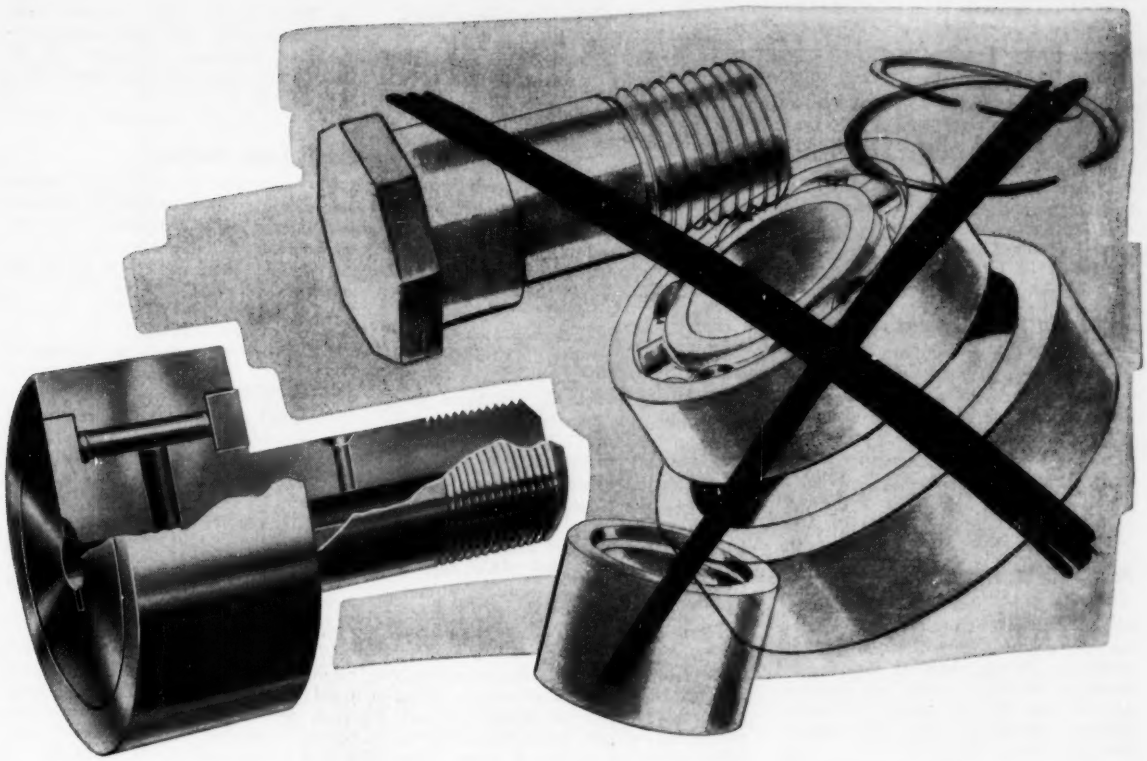
The Logan automatic lubricant dispenser handles oils, light grease, liquid soaps, tap lubricants, glycerine, and other liquids. Unit operates at 30 to 150 psi. Price list and line drawings are provided in bulletin. 2 pages. Logansport Machine Co., Logansport, Ind. J

Circle 566 on Page 19

Seamless Tubing

Special analysis Memo 121 provides preliminary data on columbium, tantalum, and vanadium small seamless tubing in wrought form. It lists physical, mechanical, and fabricating properties and compares them with Type 304 stainless steel. 6 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 567 on Page 19



McGILL® CF *CAMROL*® bearings

eliminate the cost of producing and assembling improvised cam follower, track and guide roller units

THESE CAMROL ADVANTAGES SOLVE COST, DESIGN, PRODUCTION AND PERFORMANCE PROBLEMS:

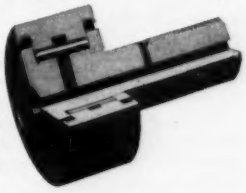
• AVAILABILITY • INTEGRAL UNIT CONSTRUCTION • HIGH LOAD CAPACITY • SMALL RADIAL SPACE REQUIREMENTS • HIGH SHOCK RESISTANCE • PRECISION ACCURACY • SIMPLIFIED LUBRICATION

You can simplify design and cut cost with CAMROL, precision cam followers. Procurement, production and assembly of components for improvised units are eliminated when you specify CAMROL bearings that are available from stock.

McGill developed the original roller bearing cam follower and perfected the CAMROL design through 25 years of application experience. Its full type construction provides exceptionally high capacity in an integral unit of a flanged, specially heat treated stud and heavy shock resistant outer race. Grease lubrication is simplified. Plain bearings require constant oil lubrication and bolt mounted ball bearings races crack under equivalent loads.

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members. Ease of interchangeability and dependable operation in any cam action, track, guide or support roller application is assured. Use the CYR series in the same roller diameters for shaft mounting.

PRE-LUBRICATED SEALED CAMROL BEARINGS



These bearings combine the advantages of CF and CYR series bearings plus effective sealing against dirt, dust and grit. Ideal in applications where lubrication is a problem. Black ferrous oxide finish resists corrosion in contaminated areas.

CAMROL bearings are available in standard roller diameters from ½" to 4". Capacities to 20480 lbs. at 100 RPM.

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McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Temperature Control Valve

The OPW-Jordan sliding gate, self-operating temperature control valve accurately controls temperatures in ventilating and process systems, heating, and cooling. Bulletin J-180 deals with operation, construction, ratings and temperature ranges, and accessory and nonstandard items offered with the valve. 4 pages. Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 568 on Page 19

Hydraulic Pipe Fittings

Flodar self-flaring, no-flare, and flare types of hydraulic tube and pipe fittings are reviewed in Catalog 556 with instructions for assembling. Sizes and engineering specifications are listed for each type. Also listed are sizes of high pressure steel pipe fittings. 26 pages. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio. G

Circle 569 on Page 19

Power Control Units

Bulletin S-1075 describes line of power control units which utilize magnetic gating amplifiers driving silicon controlled rectifiers. Devices, designed for proportional or switching control, are used for both 60 and 400 cps systems. 8 pages. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y. D

Circle 570 on Page 19

Planetary Axles

"The Story of Planetary Axles" is title of brochure which relates the development of planetary axles in association with material handling equipment. Functional operation is covered in detail on steer-drive and non-steer types. 12 pages. Rockwell-Standard Corp., Transmission & Axle Div., Detroit 32, Mich. H

Circle 571 on Page 19

Electronic Components

Handbook-Catalog 50 on military electronic components clarifies U. S. military specifications. Type designations for each spec are explained graphically. Components covered are fixed power, adjustable power, and precision resistors, rheostats, tantalum capacitors, and relays. 32 pages. Ohmite Mfg. Co., 3675 Howard St., Skokie, Ill. J

Circle 572 on Page 19

Drafting Table

French-made Stacor Unic drafting table features floating board action. A counterweight mechanism, operated by foot pedals, balances the unit. Draftsman can work on any part of the board without stretching or stooping, in seated or standing position. It is described in Bulletin SU-620. 4 pages. Stacor Equipment Co., 295 Emmet St., Newark 5, N. J. D

Circle 573 on Page 19

Gaskets & Shims

Compiled to offer selection guidance, this brochure covers gaskets, shims, washers, installation accessories, and new filler materials. Gaskets serve chemical processing, power, oil refining, heating, air conditioning, and original equipment fields. 4 pages. Akron Metallic Gasket Co., 150 N. Union St., Akron 9, Ohio. G

Circle 574 on Page 19

Silver-Zinc Batteries

Automatic silver-zinc batteries detailed in folder are for one-shot single use installations in operational weapons systems. Batteries with rectangular, cylindrical, and cylindrical sector case configurations are shown. Performance and specifications are tabulated. 6 pages. Telecomputing Corp., 3850 Olive St., Denver 7, Colo. K

Circle 575 on Page 19

Barrel Finishing

Seven-point system for controlled barrel finishing is set forth in illustrated booklet, "Carbotrol 7." It describes and illustrates an extensive line of tumbling media, barrel finishing compounds, and barrel finishing machines for a wide range of operations. 36 pages. Carborundum Co., Niagara Falls, N. Y. N

Circle 576 on Page 19

Aluminum Alloys

Technical brochure outlines the properties of Olin aluminum alloys in pig, ingot, and billet forms. Among contents are physical properties of casting alloys, comparative ratings of castings by various casting methods, and mechanical properties of casting alloys. 8 pages. Olin Mathieson Chemical Corp., 400 Park Ave., New York 22, N. Y. D

Circle 577 on Page 19

Adjustable Speed Drives

Benefits of mechanical adjustable speed drives, and how to select and specify Polydyne drives of this type are covered in illustrated Bulletin GEA-6806. Principles of operation, configurations, mounting positions, rating tables, and available accessories for the ¼ to 25-hp units are discussed. 16 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 578 on Page 19

Rotameters

General purpose, armored, laboratory and chemical, and alarm rotameters are briefly described, along with units for measuring large flows and transmitting type units for remote indicating, recording, or controlling, in Bulletin M-1. Flow indicators are also covered. 4 pages. Schutte & Koerting Co., Cornwells Heights, Bucks County, Pa. E

Circle 579 on Page 19

Electric & Lube Devices

Details of automatic oilers, chain oilers, mist coolant systems, industrial fuses, and fuse accessories are content of Condensed Catalog 59 on Trico lubricating and electrical devices. Specifications are given. 12 pages. Trico Fuse Mfg. Co., 2948 N. Fifth St., Milwaukee 12, Wis. K

Circle 580 on Page 19

Clad Copper Wire

Properties, advantages, and applications of nickel-clad copper wire are among the basic technical data contained in Bulletin T-3. It offers high electrical and heat conductivity and high temperature oxidation resistance. 4 pages. H. K. Porter Co., Riverside-Alloy Metal Div., Riverside, N. J. E

Circle 581 on Page 19

Small Lamp Holders

Various types of sockets for double and single contact candelabra bayonet, candelabra screw, miniature bayonet, miniature screw, and intermediate screw incandescent and neon glow lamps are described and illustrated in Folder LD-859. 4 pages. Leecraft Mfg. Co., 58 Greene St., New York 12, N. Y. D

Circle 582 on Page 19

Transformer

Technical data on a miniature toroidal signal transformer for low level applications where high impedance, low phase shift, and minimum pickup are required are given on data sheet. Ratios from 1:1 to 1:1000 are offered. 1 page. Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif. L

Circle 583 on Page 19

Elapsed Time Indicator

Weighing less than 3 oz, the WT-1 subminiature elapsed time indicator has jewel bearings, a 1.8 billion-to-1 gear train, and a low inertia synchronous motor. Described on Data Sheet 5001, it has a total readout of 10,000 hr. 2 pages. Waltham Precision Instrument Co., 221 Crescent St., Waltham 54, Mass. B

Circle 584 on Page 19

Rubber Products

Over 500 standard parts for which production tooling exists, are drawn to scale in M-60 Handbook on mechanical rubber products. It contains base polymer charts giving resistances of vulcanates and recommendations for use under specific conditions. Actual rubber swatches are included and extruded rubber goods are shown. 68 pages. Write on company letterhead to Lavelle Rubber Co., 424 N. Wood St., Chicago 22, Ill. I

Platinum Products

Descriptive Brochure JB57P deals with standard line of platinum products, chemicals, and recovery and refining facilities of this company. Data are also included on clads and composites of platinum group metals with base metals. 20 pages. Write on company letterhead to J. Bishop & Co., Platinum Works, Malvern, Pa. E

Variable Speed Drives

Assortment of styles, modifications, and accessories available in the complete line of Reeves mechanical variable-speed Motodrives is explained in Catalog M-592. Drives range from ¼ through 40 hp and provide infinitely adjustable speeds within ranges from 2:1 to 10:1. Specifications, speed and rating tables, and pricing information are provided. 96 pages. Write on company letterhead to Reliance Electric & Engineering Co., Reeves Pulley Div., Columbus, Ind. F

NEW WOUND FIELD MOTORS / VERSATILE

Precision miniature wound field d.c. motors in five basic frame sizes (to 2¼" OD and to 1/10 hp) and in countless variations are now available from Globe Industries. You can design them into many military and other high quality products because they meet such an enormous variety of power and duty requirements. **Examples:**

Split-series units reverse rapidly and simply with a SPDT switch. Series units start with relatively high torque, low current drain. Shunt wound varieties offer means for low current control. Universal motors operate on a.c. or d.c. Globe-designed gear reducers, brakes and clutches can be built into the unit, and Globe can efficiently design and build the motor and accessories into a special motorized device.

If you'd like to look into miniature wound field motors of **any** description, or combine them with other components, ask the largest manufacturer of precision miniature motors first. Request technical Bulletin WF-1. GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC. **GLOBE**

Circle 472 on Page 19

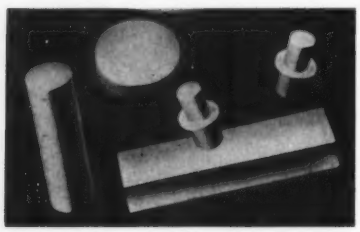
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Ceramic Transducer Element

is unaffected by temperature

US 600 ceramic transducer element has resonant frequency that is practically constant to 200 C. It also has relatively high dielectric constant and low mechanical Q of 45. Material is suited for use either as a sensor or high-power driver. Applications include underwater sounding, thickness-gage detectors, and IF filter or ladder networks. Radial coupling coefficient is 0.46



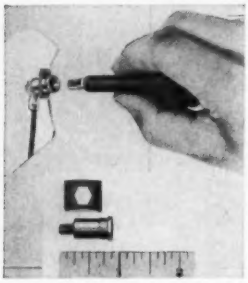
and linear coupling coefficient is 0.67. Upper Curie temperature is 310 C. Ceramic is available in all required sizes and shapes. **U. S. Sonics Corp.**, 625 McGrath Highway, Somerville, Mass. B

Circle 585 on Page 19

Panel Receptacle

provides rapid power connection

Designed for rapid assembly into any electrical panel, and affording fast, positive means for connecting and disconnecting wires, Model WA-014 receptacle with mating plug can be panel mounted in seconds without special tools. Only 7/8 in. long, it is knurled to prevent rotation when pressed into a panel or insulating strip and is locked into position by a push-on type nut from rear. Threaded stud is provided for fastening to power-source terminal lug. Receptacle, with insulated mating plug, provides a



rapid method for connecting and disconnecting electrical wire. Plug and receptacle incorporate positive-locking connection with high-pressure contact, which eliminates accidental uncoupling. **Cam - Lok Div., Empire Products Inc.**, P. O. Box 98, Cincinnati 36, Ohio. G

Circle 586 on Page 19

Transistorized Timer

handles 25 amp, 32 v inductive

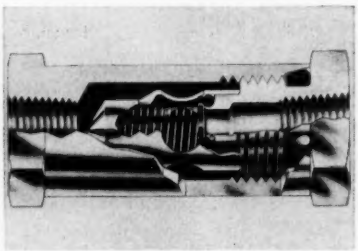
High-current-capacity transistorized timer, designed for electronic timing applications where multiple pulsing can be used to trigger a number of programming functions, is now available. Model TMC-PG-1 miniaturized, transistorized timer is basically a free-running pulse generator with externally adjustable period and pulse. Built to operate on 18 to 32 v dc at 60 ma max, it handles 25 amp, 32 v inductive over ambient temperature range of −55 to 125 C. Unit withstands 10 g vibration from 5 to 2000 cps and shock of 50 g for 11 millisec. Applications include operation of high-speed cameras and triggering of sequential programmers. **Timech Corp.**, 13866 Saticoy St., Van Nuys, Calif. L

Circle 587 on Page 19

Check Valves

for 3000 psi pressure in air, oil, water

Check valves, Series 750, provide extremely low back pressure and fast action. Built for 3000 psi in air, oil, and water, they have standard cracking pressure of 0.5 psi, with higher cracking pressures available on order. Lower opening pressures, down to 1/16 psi, are available from stock. Valves are leakproof at all pressures. Disc-type valves are very sensitive to reversal of flow and act rapidly. They are presently available in brass in



1/8-in. pipe size in all standard fittings. **Bodnar & McDermott Mfg. Co.**, 19 Beechwood Ave., Mt. Vernon, N. Y. D

Circle 588 on Page 19

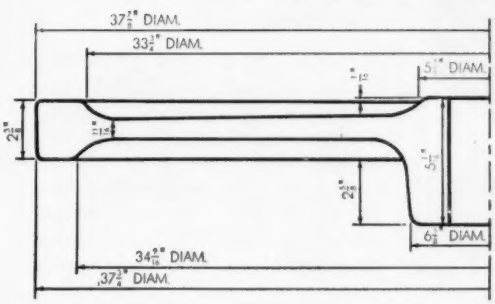
Track-Resistant Laminate

for service in humid, contaminated atmosphere

Grade UTR Resistrac glass-fiber polyester laminate offers advantages in apparatus operating at voltages over 1 kv or applications with short creep distances, particularly where humidity and surface contamina-

GEAR *installed in hoist mechanism of Koehring Company power shovel.*

EXCELLENT *response to induction hardening? Take a look!*



NOTICE *the thin disc shape on this 395-lb gear blank. A cinch on the Slick Mill!*

This gear now costs $35.24 less,

THANKS TO BETHLEHEM CIRCULAR FORGINGS

"We are also very pleased with product machining properties, freedom from defects in the tooth area, and excellent response of the forging to heat treatment."

KOEHRING COMPANY, MILWAUKEE, WISCONSIN
manufacturers of construction equipment

Koehring Co. previously machined this gear from a cast gear blank. Today they machine it from an impression-die steel forging made on Bethlehem's unique Slick Mill. They save $29.24 in first cost, plus $6.00 in machining costs! (Turning, boring, facing, and hobbing teeth.)

Here's how we do it

The answer, of course, lies in Bethlehem's Slick Mill—the only one of its kind in the country. Quick die set-up (only 15 minutes)—quick operation (just one minute to forge and roll a circular product)—low die charges (⅓ to ½ less than conventional impression dies)—and less steel needed (utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength) . . . all these add up to important savings. At the same time, the process insures *soundness, excellent grain flow,* and *machinability.*

Bethlehem's Slick Mill saves the Koehring Company $35.24 *per gear.* How much can it save you?

Bethlehem Circular Forgings are available in carbon, alloy, or stainless steels, as well as certain heat-resistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled, or rough-machined to specifications. Call or write the Bethlehem sales office nearest you for full details.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

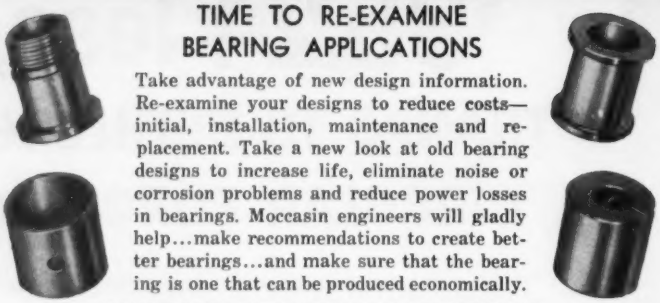
BETHLEHEM STEEL

Circle 473 on Page 19

Moccasin BRONZE SLEEVE BEARINGS

TIME TO RE-EXAMINE BEARING APPLICATIONS

Take advantage of new design information. Re-examine your designs to reduce costs—initial, installation, maintenance and replacement. Take a new look at old bearing designs to increase life, eliminate noise or corrosion problems and reduce power losses in bearings. Moccasin engineers will gladly help...make recommendations to create better bearings...and make sure that the bearing is one that can be produced economically.



MOCCASIN PRODUCES THE FOLLOWING:

Special sizes of cast bronze sleeve bearings. All sizes up to 48" diameter and 1000 pounds. A complete line of 13" machined bronze bars. All bronze bearing alloys stocked and available. Centrifugal, permanent mold and sand casting facilities. All types of half and split bearings—self-aligning bearings—thrust washers—segment bearings. Gear blanks furnished in the rough or machined ready for hobbing. Rough castings for any bearing parts. Graphited bearings made in various styles. Moccasin Oil Distributing Bearings. All bearings and parts unconditionally guaranteed.

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"Quality Bronze Since 1908"

MEMBER OF CAST BRONZE BEARING INSTITUTE

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Circle 474 on Page 19

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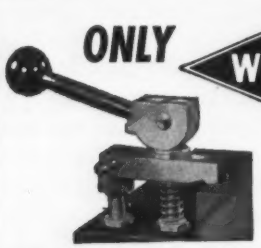

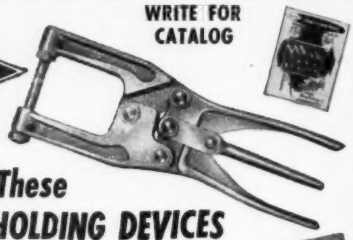

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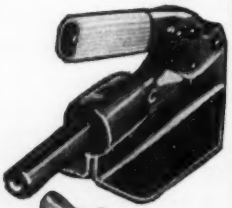
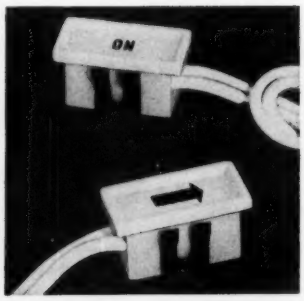


tion conditions are present. Material is flame retardant and track resistant, and other physical and electrical properties meet NEMA GPO-1 specifications. Laminate is available in standard sheet sizes of 36 x 72 in. and 24 x 36 in., in thicknesses of $\frac{1}{8}$ through $\frac{3}{4}$ in. Other thicknesses are available upon request. **Glastic Corp.**, 4321 Glenridge Rd., Cleveland 21, Ohio. G

Circle 589 on Page 19

Neon Indicator Light

indicates passage of electric current



Neon indicator light is composed of a long-life, 1/25-w neon lamp enclosed in a translucent urea plastic case. It has use in a wide variety of products and applications to indicate passage of electric current. Unit is fitted with self-adjusting mounting clips, permitting fast insertion on 0.031 to 0.093-in. metal, and it also fits perforations of most standard switchplates. Light is available for either 125 or 250 v, with white or red translucent case, and with choice of several standard imprints. **Westmoreland Plastics Co. Inc.**, Gertrude Street, Latrobe, Pa. F

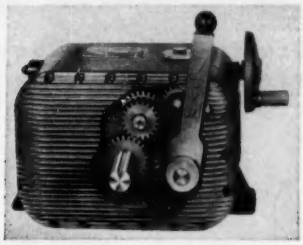
Circle 590 on Page 19

Adjustable-Speed Controls

are available with instant reversing

Zero-Max heavy-duty, fractional-horsepower, adjustable-speed controls can be reversed instantly whether running or stopped, increasing maximum torque limit at which instant reversing is possible from 100 to 450 lb-in. Reverse is accomplished by a bell-crank mechanism controlled by a lever incorporated

Circle 475 on Page 19



in gearheads for ½ and ¾-hp units. Reversing device makes instant reversing available as an accessory on all Zero-Max transmissions. Basic unit converts up to 1850 rpm input to an infinitely variable range of 0 to 400 rpm. Gearheads step up output to increase range to 0 to 2000 rpm, or gear reduction cuts speed but increases torque ratings to 450 lb-in. **Revco Inc.**, 1900 Lyndale Ave. S, Minneapolis 5, Minn. J

Circle 591 on Page 19

Potting Compound

for use at temperatures to 1500 F

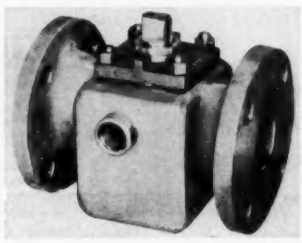
Temporell No. 1501 high-temperature electrical potting compound and adhesive is designed for use at temperatures from −65 to +1500 F. It is a heat conductor and electrical insulator. Material adheres to metal, glass, and ceramics, but is not adhesive to rubber. Practically inert and nontoxic, it is not sensitive to thermal shock when cured. **Orell Inc.**, Box 527, South Gate, Calif. L

Circle 592 on Page 19

Sleeved Valves

have jacketed construction

Tufline sleeved valves, designed for special applications involving heated or cooled media, are available in jacketed construction in standard 150 and 300-lb two and three-way bottom-entry designs. Valves feature a Teflon sleeve which keeps



Onan NEWS REPORT

Onan 13 H.P. engine powers 100-mile-an-hour air blast!

This Model 50 Rotomist, manufactured by the John Bean Division of Food Machinery and Chemical Corporation, is a highly mobile mist sprayer used for pest control, sanitation, and treatment of tree diseases. Powered by a 13 horsepower Onan CCK engine, the Rotomist delivers 12,000 cubic feet of air per minute at a velocity of 100 miles per hour.

The Onan CCK offers unique advantages for this type of mobile application. It is capable of *sustained operation at over 3,000 r.p.m.* Alternate-firing, two-cylinder, opposed design is compact and *free from vibration*. Extra-large bearings and rugged construction make it a dependable, long-life power source.

Give *your* equipment a performance *bonus* with Onan CCK power!

Onan Model CCK-Gasoline or gas-powered

- Over-square design; 3¼-inch bore; 3-inch stroke.
- Rotating Stellite-faced exhaust valves.
- Solid Stellite exhaust valve seats.
- Full pressure lubrication.
- Axial-flow cooling.
- Short, extra-heavy crankshaft.
- 3-quart oil sump.
- High tension magneto ingition.

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Call the Onan distributor listed in your telephone book or write for complete specifications.

D. W. ONAN & SONS INC.

ELECTRIC PLANTS GENERATORS ENGINES ENGINE-COMPRESSORS
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Onan PRODUCTS

Circle 476 on Page 19

put HEINZE in your designs

these

HEINZE D2 BLOWERS
are REAL COOL

Like wow! Heinze D2 Blowers, with durable plastic housings, are ideal for circulation of air, for cooling electronic components and equipment, and for cooling operations in vending machines, laboratories and similar applications.

Powered by the exceptionally long-lived Type D 2-pole shaded pole induction motor, single blower unit delivers 10 cfm (free air), double unit 20 cfm, at 3100 rpm. Rated for 115 V, AC, 60 cycles, blowers are also available for 50 cycle operation. CW or CWW rotation.

Standard units are available from stock for immediate delivery. Send coupon for complete technical data.

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Sub-Fractional Horsepower Motors and Blowers

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685 Lawrence St., Lowell, Mass.

Please send literature and prices on the entire line of Heinze Blowers.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 477 on Page 19

valve tight without readjustment, and allows for expansion and contraction of Teflon over wide ranges of temperature and pressure. Sleeve also eliminates need for lubrication. Valves have an integral jacket that surrounds body bore to permit heating or cooling medium to be introduced. Three ½-in. threaded holes located on opposite sides and bottom permit inlet, outlet, or draining access to jacket. Valves are wrench operated in flanged-end sizes from ½ through 3 in., and gear operated in sizes from 3 through 6 in. **Continental Mfg. Co.**, 247 Park Ave., New York 17, N. Y. D

Circle 593 on Page 19

Knob Potentiometer

for use where high accuracy is unnecessary

Model K-050 potentiometer is a ½-in. knob type for solving problems of extreme miniaturization in a variety of electronic equipment where high accuracy is not necessary. A wire-wound unit of low wattage, it is completely encased in a sealed, watertight, metallic housing. Potentiometer conforms to military specifications and has an operating temperature of −55 to +55 C. Stud-mounting design with hex nut permits front-panel control. Mechanical and electrical rotation are 340 deg. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

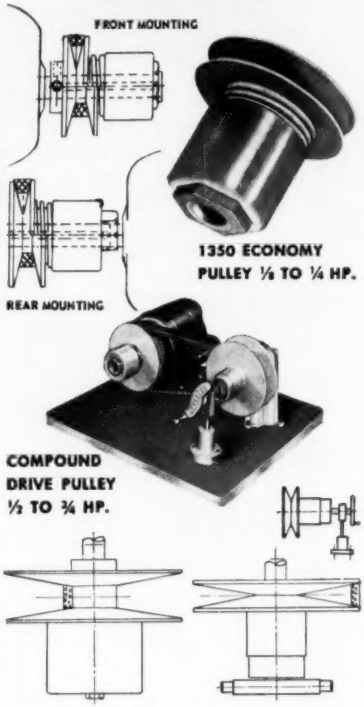
Circle 594 on Page 19

Flexible Hose

retains flexibility at IDs to 2 in.

Teflon and stainless steel are combined to form Springfield 400 flexible hose. Inner core is made of Teflon tape and Teflon-impregnated glass-fiber tape. With bend radius

Lovejoy
Fractional Horsepower
VARIABLE SPEED PULLEYS



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low in initial cost . . . easily installed on old or new equipment.

Minimum Maintenance—
simple construction assures trouble-free operation . . . lifetime lubricated with oil-impregnated bronze bushings.

Constant Belt Alignment—
inner and outer pulley sheaves open equally to provide smooth, infinitely variable speed ratios to 8 to 1.

No Slippage—
Sure grip of belt sides delivers full traction under all load conditions...result is greater horsepower carry capacity.

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LOVEJOY FLEXIBLE COUPLING CO.
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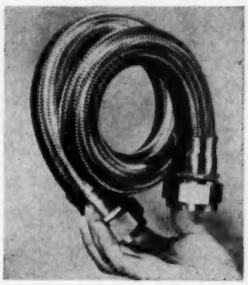
Circle 478 on Page 19



approximately three times its ID, hose operates at temperatures to 400 F and is available with ID to 2 in. Use of Grade 304 stainless-steel braid wire provides high tensile strength, corrosion resistance, and ability to operate under high impulse pressures. Hose is currently rated for pressures to 500 psi. Sizes and styles of fittings are determined by hose ID and end use application. Fitting sizes now available are ¾, 1, 1¼, 1½, and 2 in. ID. Standard terminations include AN 37-deg swivel nuts, MS 20756 flanges, JIC terminations, and male pipe threads. Materials for fittings include stainless and cold-rolled steel, with aluminum available for lightweight assemblies. **Titeflex Inc.**, 508 Hendee St., Springfield 4, Mass. B

Circle 595 on Page 19

Shock-Vibration Isolators

for use at temperatures to 500 F

Isomode isolators provide shock and vibration protection at high temperatures encountered in high-performance aircraft and missiles. Isolators consist of two load-carrying springs, mounted in opposed positions, with built-in damper assembly to restrict resonant build-up. Isolators provide desired performance when directly exposed to high temperatures, and no external cooling is required. Design can restrict

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NEW
GLACIER DU WITH ANY OTHER
DRY BEARINGS!
DU wears 10 to 100 times longer
DU has low breakaway torque . . . no slip-stick
DU has highest compressive strength—no cold flow
DU lets you predict minimum service life

DU is as close to the perfect dry bearing material as you will find today. It is a patented composite material consisting of a steel and porous bronze interlayer impregnated with a lead-filled TFE* fluorocarbon resin.

The compressive strength of DU is approximately 51,000 psi. DU is capable of operating at higher velocities than other dry bearings in many problem liquids and at temperatures from −328° F. to + 536° F. Thus DU is suitable for many applications ranging from liquid gas pumps and compressors to high temperature oven conveyor systems.

Most important, with DU the designer can quickly and accurately predict bearing life for specific applications. The unique characteristics of DU make possible establishment of curves relating bearing life to any load-speed conditions. These curves and other important design data are included in Bulletin DU-458. Ask your bearing manufacturer, or write to SPECIAL PRODUCTS DEPT., United States Gasket Co., Camden 1, N. J.

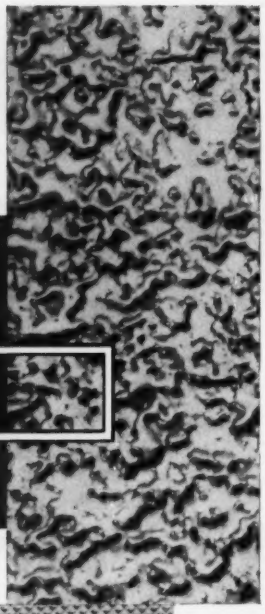
*Teflon, DuPont Trademark
Fluon, I.C.I. Trademark

United States Gasket
Plastics Division of GARLOCK

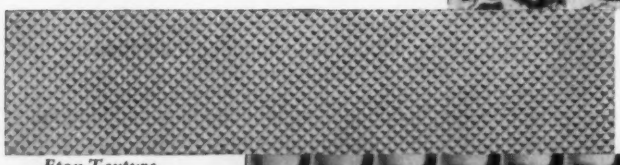
Circle 479 on Page 19

ARDMORE TEXTURED METALS

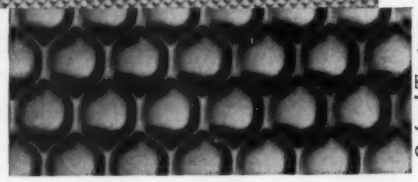
give you . . a PLUS factor



Leeds Texture



Eton Texture



Oxford Texture

There's more to Textured Metal than meets the eye! Sure, distinctive appearance is important . . . it attracts customer interest and adds buy-appeal, but Ardmore Textured Metal gives you a *plus* factor . . . it's functional, too.

The three-dimensional surface sheds wear and abuse — adds years to product life and minimizes costly rejects during fabrication. Increased strength often permits gauge reductions which save you material, weight and money. That's not all . . . controlled light diffusion, non-skid, increased surface area for heat transfer or dissipation, acoustical and many more inherent qualities make Ardmore Textured Metal the practical designer's material. Also consider the great latitude of design change possibilities (without accompanying high tooling costs) offered by the wide selection of stock Ardmore textures and finishes. Doesn't it make sense to you that a material with the *plus* factor offered by Ardmore Textured Metal . . . bears investigation?

Available in *all* metals, any finish, solid or perforated. Eight new exciting textures in sheets up to 52" in width or continuous coils to 48" width. Multiples, blanks or finished parts are furnished to your specifications. Ample inventory and modern high-speed equipment assure you prompt service — economical pricing.

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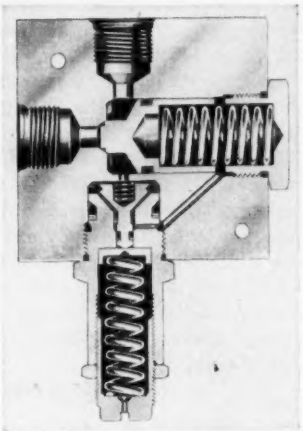
Circle 480 on Page 19

maximum resonant build-ups in the low-frequency range to well below 3½:1 in any direction of vibration without sacrifice of high-frequency isolation efficiency. Units can be furnished with equal spring rates in all directions. Mounts pass MIL-E-5272A vibration and shock requirements. **MB Electronics, Div., Textron Electronics Inc.**, Box 1825, New Haven 8, Conn. B

Circle 596 on Page 19

Gas Relief Valve

for pressures from 1000 to 7000 psi



Seating force increases as pressure rises in new gas relief valve, resulting in a tight, leakproof unit. Cracking pressure, reseat pressure, and full-flow pressure are all very close, assuring quiet opening and chatterfree operation, even at high pressures. Standard connections are internal straight threads, ¼ to ⅝ in., internal pipe threads, ⅛ to ½ in., and U. S. Bureau of Standards high-pressure tube, ⅜ and 9/16 in. Body and internal parts are stainless steel. Unit accommodates pressures from 1000 to 7000 psi. Standard temperature range is −65 to 160 F. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio. G

Circle 597 on Page 19

Silicon-Controlled Rectifiers

inverter-type units have fast turn-off time

Silicon-controlled rectifiers are specifically designed for direct to alternating current inversion, dc static

switching, pulse-width modulation, power-equipment frequency conversion, and current-limiting circuit-breaker use. Inverter-type controlled rectifiers have maximum 12 mu sec turn-off time at highest rated junction temperature. Five rectifiers are available in peak-inverse-voltage ratings of 100, 150, 200, 250, and 300 v. Fast turn-off characteristic permits use at frequencies in 10 to 20-kc range. In inverter applications they permit more efficient circuit operation than conventional silicon-controlled rectifiers and allow better voltage regulation. Devices are rated for operation in junction-temperature range from −65 to +125 C. **Semiconductor Products Dept., General Electric Co., Liverpool, N. Y.** N

Circle 598 on Page 19

Safety Switches

are rated from 400 through 1200 amp

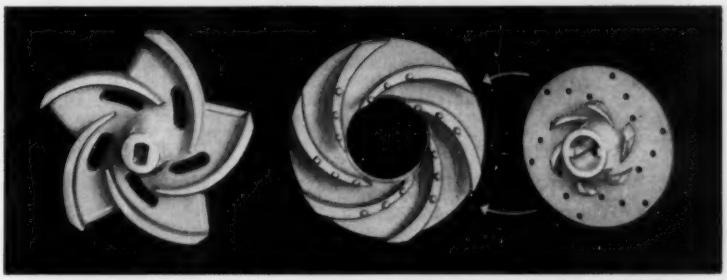
Quick-make, quick-break safety switches are manually operated circuit interrupters employing a circuit-breaker operating mechanism in conjunction with fuses. Rated from 400 through 1200 amp, they have 100,000 amp interrupting capacity when current-limiting fuses are inserted. Contacts are driven into position accurately in less than one cycle, assuring long contact life, clean contacts, and reliable performance. Lever-type handle action requires less than 60-deg throw to

Circle 481 on Page 19→

profiles in plastics

by **B. FRANK HANTZ,** *Vice President*
AMERICAN INSULATOR CORPORATION
One of The Men Behind The Man From Aico

"Aico's enviable position in the field of molded plastics has been attained largely through customer satisfaction and service. Since 1916, Aico has been a major supplier of molded plastics to many of America's pace-setting industries. Each molding job presented its own unique problems . . . problems which were successfully solved by the integrated facilities and coordinated skill of expert craftsmen within the Aico organization. Perhaps the best proof of Aico's efficient service . . . and satisfaction delivered . . . is the record of new assignments we receive from customers we've served in the past."



MOLDED NYLON PUMP IMPELLERS
ANOTHER NEW USE OF AICO PLASTICS

These nylon pump impellers are typical examples of how better products result from the use of Aico Molded Plastics. Molded to extremely close tolerances, providing precision accuracy without machining, the nylon impellers reduce assembly costs while increasing pump efficiency. Their light weight conserves driving energy. The chemical, corrosion and wear resistant qualities of the nylon material promises longer impeller life and less pump maintenance. Aico Molded Plastics can give your products new, *impelling* sales advantages, too. Discuss them with Aico now.

FREE Plastics Designer's Handbook

Shows how good design controls unit cost of molded plastics. Molded plastic parts with a low unit cost can be achieved only when the practical limitations of die-making are given full consideration when the part is being designed. Aico has prepared a Plastics Designer's Handbook that tells and illustrates how costly design errors can be avoided. A FREE copy is yours on request . . . use coupon below.

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INSERTS . . . may be used in plastic parts as fasteners, to support loads, simplify handling or facilitate assembly. (They may serve functional purposes or may be used purely for decoration.) Smooth rod inserts (see sample above) may be securely anchored by bending, splitting, notching, swaging or knurling. Other types of inserts are fully covered in Aico's booklet "Good Plastics Design Makes Cents." Coupon will bring your FREE copy.

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The Design Equation that Saves You Money...

Use easy-to-install, economical National Retaining Rings to locate and position bearings or parts on pins, shafts and in housings. Eliminate grinding or machining shaft stock to form shoulders. You save time and material and reduce weight and space requirements. Ask for data on your specific application, today!

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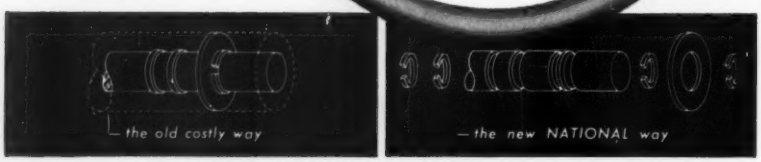
= improved design + economy!



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by John D. Vandenberg and C. Thomas Goldsmith

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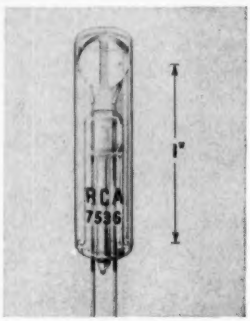
operate interlock and switch mechanism. Three enclosure sizes are available, one for 400 and 600-amp switches, another for 800-amp units, and a third for 1200-amp switches. **Federal Pacific Electric Co.**, 50 Paris St., Newark 5, N. J. C

Circle 599 on Page 19

Photoconductive Cell

for light-operated relay applications

No. 7536 small, cylindrical, side-on type, cadmium-sulfide photoconductive cell is for use in a variety of industrial light-operated relay applications. Unit has illumination sensitivity of 300 mu amp per ft-c at 25 C, maximum current capa-



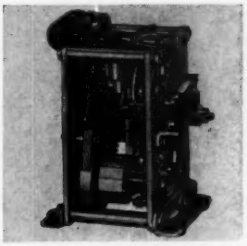
bility of 1000 mu amp, and maximum power-dissipation rating of 50 mw. Photosensitive area is 0.2 x 0.02 in. Voltage applied between terminals can be as high as 200 v. Cell is hermetically sealed in a glass envelope to permit operation under conditions of high humidity. Maximum diameter is 0.3 in. and maximum length (excluding flexible leads) is 1.35 in. **Electron Tube Div., Radio Corp. of America**, Harrison, N. J. D

Circle 600 on Page 19

DC Motors

produce high torque with low current drain

Constant-speed dc motors and timers provide accuracy of speed even with wide voltage and load fluctuations. They provide a dependable means for controlling circuits from a battery or other dc power supply. High torque produced with low current drain, plus rigid construction, make motors suitable for applications requiring a



high degree of accuracy and dependability under severe vibration, gravity, and temperature conditions. With operating voltage ranging from 3 to 110 v dc, and 0.06 to 2 w input, torque up to 150 oz-in. can be produced at 1 rpm. Suitable speed from 900 rpm to 1 revolution in 24 hr or more can be provided. **Amglo Corp.**, 4325 N. Ravenswood Ave., Chicago 13, Ill. J

Circle 601 on Page 19

Lubricant

for use at
high temperatures

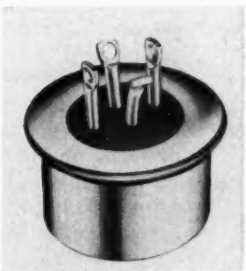
Dag 207 is a concentrated dispersion of colloidal molybdenum disulfide in an LB series Ucon lubricant. It resists settling, and lubricates at temperatures above point where most petroleum oils carbonate. Typical uses are on oven conveyors, kiln cars, gears and bearings, and glass machinery. **Acheson Colloids Co.**, Port Huron, Mich. H

Circle 602 on Page 19

Precision Thermostats

are fixed-temperature set
within −65 to +300 F range

Hermetically sealed, three-phase precision thermostats, Series 2862, are for wye-connected circuits. Thermostats, actuated by snap-acting bimetal discs, are fixed-temperature set within −65 to +300 F range. Switch action is three circuit,



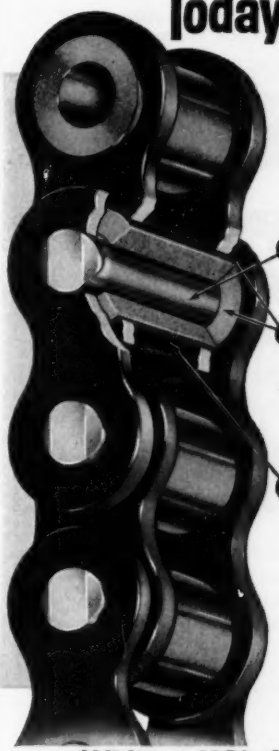
PROGRESS IN POWER TRANSMISSION CHAIN DESIGN

In 1953...

Whitney introduced the first oil-impregnated, sintered steel bushing roller chain — a major advance in chain design.

Not content with leading the field with the first sintered bushing chain, Whitney Engineers continued their exhaustive field research... carried on searching studies of the original sintered bushing chain in an effort to produce an even better chain with optimum performance characteristics. Their work, coupled with recent developments in sintering technology, resulted in the development of MSL Chain—a completely new concept in power transmission chain.

Today...



WHITNEY MSL* CHAIN... a product of continuing Whitney Research—is another giant step forward in chain technology because it advances and improves on the basic idea of oil-impregnated, sintered steel bushings in power transmission chain.

Only Whitney MSL Chain with oil-impregnated bushings assures complete built-in lubrication at all three critical lubrication areas:

1. **Pin**—Protective film of oil completely lubricates the live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.
2. **Plates**—Whitney oil-impregnated sintered steel bushings extend beyond surface of inside plates to act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.
3. **Sprocket Engagement**—MSL Chain does not require rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

Inherent material characteristics of Whitney sintered steel bushings, plus bushing configuration that provides greater contact area between bushings and links, permit high interference fit, which pre-loads links and gives maximum fatigue resistance.

Whitney MSL Chain meets ASA Standards

It is made in Standard and Extended Pitch types, and is completely interchangeable with any similar pitch ASA Standard chain. For full details, write for MSL Catalog G1-59, or call your nearby Whitney Chain Distributor. who carries MSL Chain in stock for quick delivery.

***Maximum Service Life**

Whitney *Advanced Design Is a Whitney Tradition*
CHAIN COMPANY

A Subsidiary of Foote Bros. Gear and Machine Corporation

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CHICAGO 9, ILLINOIS

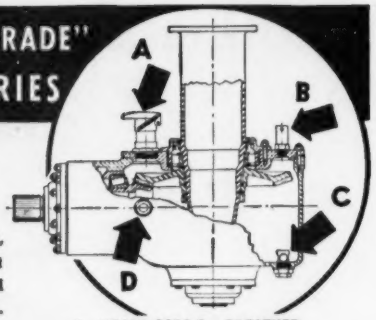
Circle 484 on Page 19

TEDECO "AVIATION GRADE"
GEAR CASE ACCESSORIES

SELF CLOSING MAGNETIC
DRAIN PLUGS

Permit convenient, direct, visual inspection without loss of fluid, no special tools, no electric gadgets. Automatic valve closes when magnetic plug is removed. Matching drain lines available.

THREADED OR BAYONET



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FILLER CAPS

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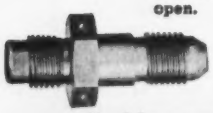
Reflector assures visibility even in dark areas. Shows median level in agitated fluids. Easily installed in tapped holes.



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Circle 485 on Page 19

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Circle 486 on Page 19

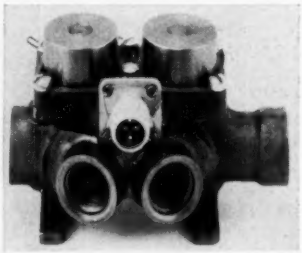
SPST, and can be made to either open or close on temperature rise. Electrical rating is 208/115 v ac, 60-400 cps, three phase, 10 amp resistive, 6000 operating cycles. **Metals & Controls Div., Texas Instruments Inc.**, 34 Forest St., Attleboro, Mass. B

Circle 603 on Page 19

Selector Valve

has stainless-steel body with integral sleeve

HP663100 four-way, three-position, solenoid-operated selector valve uses a forged stainless-steel body with sleeve as an integral part. Design eliminates more than half the number of packings usually required. Unit is for pressures to 3000 psi



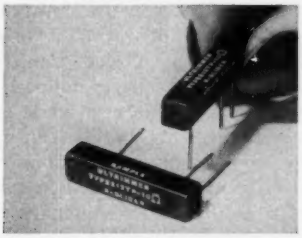
and temperatures to 275 F. Each position is pressure actuated, eliminating dependence on springs. **Hydra-Power Corp.**, Pine Court, New Rochelle, N. Y. D

Circle 604 on Page 19

Trimming Potentiometer

for printed-circuit use

Ultrimmer trimming potentiometer withstands severe shock and vibration. It is designed specifically for printed-circuit use. Resistance element is embedded in alkyd resin which eliminates strain coefficient during temperature cycling, assuring that no synthetic temperature coefficient will occur. Maximum temperature coefficient is 25 parts per million per deg C. Potentiometer can be supplied for transistor circuitry with high positive temperature coefficient. It has welded construction and Teflon-insulated lead wire. Humidity and moisture are shut out by silicone-rubber O-ring which also maintains constant turning torque. Special clutch arrangement prevents overtravel or jam-



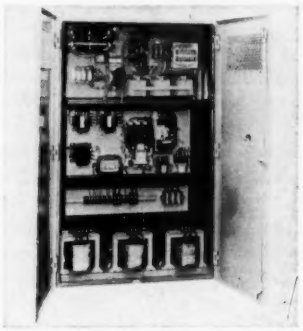
ming of slider, and assures positive starting grip on positioning screw. Unit is available in rectangular case, measuring only ¼ x ¼ x 1¼ in. **Ultronix Inc.**, 111 E. 20th Ave., San Mateo, Calif. M

Circle 605 on Page 19

Variable-Voltage Control

drive is for
1 to 200-hp motors

All-static variable-voltage control, Type AVR, called Reactifier Drive, is available for applications in machine tool and automotive industries. Drive is for 1 to 200-hp motors operating on either 50 or 60 cycles. Supply of three-phase, 208/220 or 440-v power can be used. Unit provides constant torque over 8:1 speed range. Magnetic amplifiers, power reactors, and silicon diodes provide low maintenance, long life, and extreme reliability. Control is furnished in floor-



mounted cabinet. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa. F

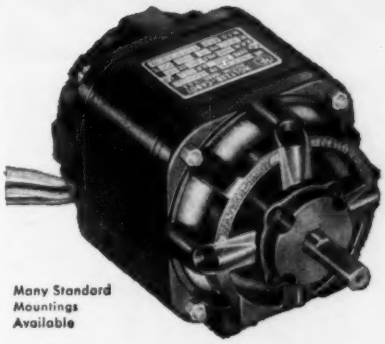
Circle 606 on Page 19

DC Reset Timer

accurate unit
has automatic reset

Direct-current reset timer for automatic control of industrial and machine-process functions controls dc loads within variable timed inter-

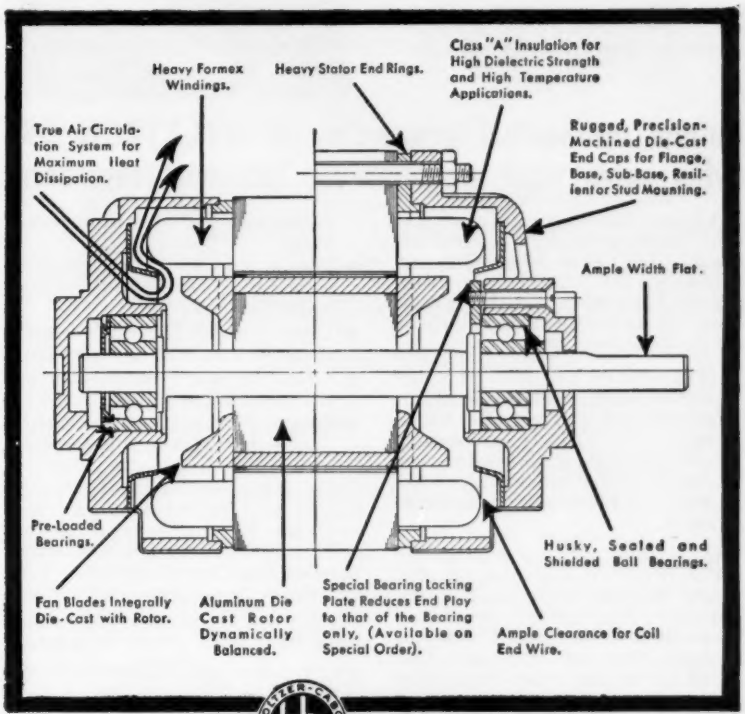
Instrumentation Motors from HOLTZER-CABOT



Many Standard Mountings Available

TYPE R-29 MOTOR
2⅞" Diameter

This motor is an ideal power source for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communications equipment, etc. It is available in both 2-pole and 4-pole design, each in three stacking lengths. Type R-29 is a permanent split capacitor type available as an induction or synchronous motor. H.P. of various models ranges from 1/75 to 1/30. Construction features are indicated below.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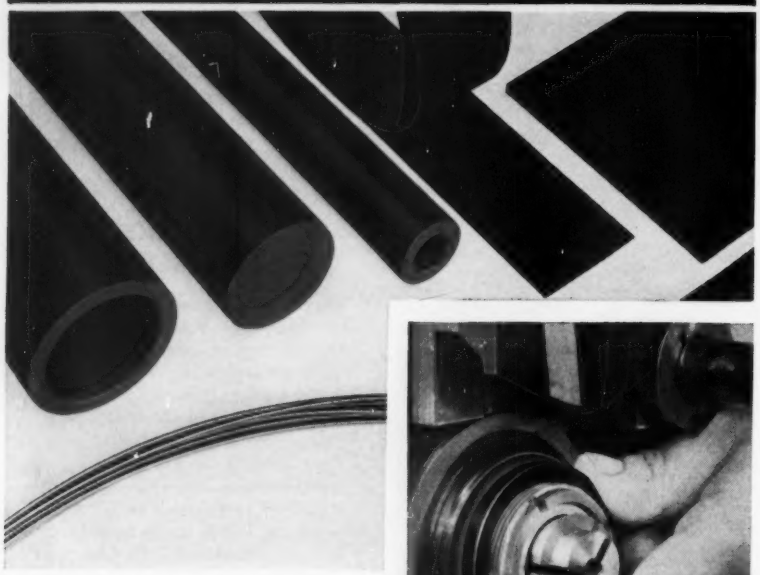
Circle 487 on Page 19

NYLATRON® GS NYLON



Selection of NYLATRON GS nylon for critical automatic screw machine application (right) again proves its value as an outstanding material for today's designers.

Unique mechanical properties of NYLATRON GS nylon solve vital problems for industrial engineers

• A leading manufacturer of automatic screw machines needed a material for use as a seal, which is spring loaded between the spindle and bearing retaining nut. After testing, the design engineers selected NYLATRON GS nylon for these reasons:

NYLATRON GS nylon is tough without being brittle. It formed a positive seal and provided longer wear. NYLATRON GS washers were economically machined to close tolerances from bar stock, provided uniform concentricity and an exacting fit.

The unique characteristics of NYLATRON GS are the result of a special formulation: a molybdenum disulphide filled nylon*, particularly adaptable as a material for bearings, bushings, liners and other parts subjected to extreme wear. Note these improved mechanical characteristics:

★ Greater Rigidity—higher modulus of elasticity, less deformation under load.

★ Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.

★ Lower Thermal Expansion—coefficient less than 65% of nylon 101.

★ Lower Surface Friction—can be used without lubrication.

★ Greater Wear and Abrasion Resistance—can outlast, outperform metal.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for new booklet on NYLATRON GS—or other nylon formulations to meet your specific requirements.

*Patented for composition and use for machine parts

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vals or sequences with repeat accuracy of 0.25 per cent. It resets full-scale length in less than 0.1 sec, or stops on power failure or power interruption. Seven basic circuit arrangements provide an infinite number of combinations for control of automatic functions, and metal-to-neoprene impingement clutch allows millions of operations without clutch wear or slippage. Series 305 also features self-cleaning, heavy-duty silver contacts and wiring schematic printed on cover to eliminate errors in circuit identification. Power requirements are 6,

12, 24, 28, 32, 48, 125, or 250 v dc. **Automatic Timing & Controls Inc.**, King of Prussia, Pa. E

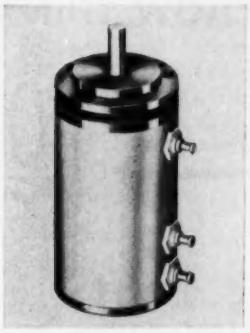
Circle 607 on Page 19

Ten-Turn Potentiometers

have stop strength of 128 oz-in.

Two standard temperature ranges are available in ⅞-in. diam, ten-turn precision potentiometers. Model 7220 has power rating of 2 w at 25 C, derating to zero at 85 C; Model 7230 is rated at 2 w at 65 C, derating to zero at 125 C. Both have minimum operating temperature of −55 C. Standard resistance range of 7220 is 10 to 125,000 ohms ±5 per cent, and of the 7230, is 300 to 90,000 ohms ±5 per cent. Rugged stop strength of 128 oz-in. prevents damage to component or system caused by servo motor overshoot. Other mechanical features include 0.2 gm-cm² moment of inertia, 0.6 oz-in. starting torque, 0.5 oz-in. running torque, 0.6 deg backlash, and 0.003 in. end play. Environmental requirements of NAS 710 and MIL-R-19 are met or exceeded. Three mounting styles are available in 7220 models; 7230 is available at present only with servo mount and

Circle 488 on Page 19



ball bearing. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 608 on Page 19

Lightweight Relay

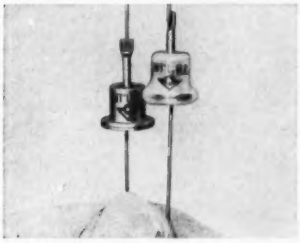
in ac and dc units

E410H relay is a 10-amp, four-pole double-throw unit available in both ac and dc-operated types. Lightweight, space-saving relay is fully qualified under MIL-R-5757C, MIL-R-25018, and MIL-R-6106C. Overall enclosure is only 1.44 x 1.44 x 2.25 in., and weight is 0.4 lb. **Electro-Mechanical Specialties Co. Inc.**, 743 W. 39th St., Banning, Calif. L

Circle 609 on Page 19

Teflon-Insulated Diodes

mount in close quarters



Silicon pigtail diodes are available with insulating Teflon coating over diode case, for circuitry where bank-mounting or other close-quarter mounting procedures are used. High-temperature, chemical-resistant jacket permits extremely close positioning of diodes, eliminating possibility of diode cases shorting to other components or to chassis. Insulating jacket maintains its electrical and mechanical properties from −67 to +250 C. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 610 on Page 19

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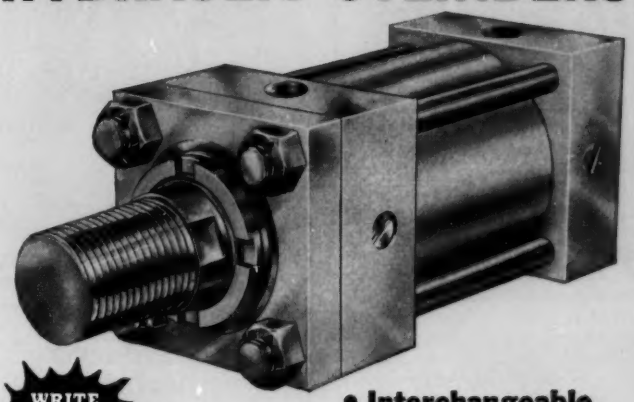

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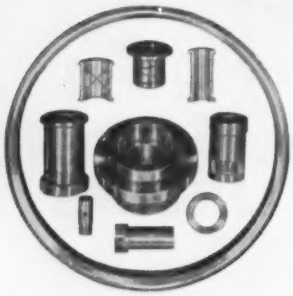
A LITTLE STUBBORNNESS GOES INTO OUR SLEEVE BEARINGS



Producing bronze sleeve bearings requires more than special tools and techniques. It demands proven design experience such as we have acquired through 25 years of bronze bearing production. That's why we seem so insistent sometimes in our efforts to help with your bearing design. We have learned the hard way and are more than willing to share our experience with you. When we are convinced that a change will improve the bearing, cut production costs or ease assembly operations, you'll find our objections firm though constructive.

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Circle 490 on Page 19

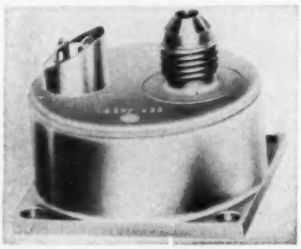
ENGINEERING DEPARTMENT

EQUIPMENT

Pressure Transducer

miniature unit resists high vibration

Miniature pressure transducer, Model 725, is designed for extreme vibration environment. It is available in 11 standard pressure ranges from 0-200 to 0-5000 for measurement of pneumatic and hydraulic media. Resistance elements are available from 1000 to 10,000 ohms, and power rating of unit is 1 w. Transducer employs bourdon-type movement that offers reliable, accurate operation during extreme vibration. Basic instrument is 1¾ in. in diam and ⅞ in. high. **Bourns Inc.**, P. O. Box 2112, Riverside, Calif. L



Circle 611 on Page 19

Control Valves

for laboratory and research use

Micro regulating needle and fingertip control valves in sizes from ⅛ to ½ in. are furnished in stainless steel, Monel, and Hastelloy. Valves are particularly recommended for applications involving processing of

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Circle 491 on Page 19

viscous and volatile liquids, and for gases at high and low temperature, pressure vacuum and corrosion conditions. **Whitey Research Tool Co.**, 1150 55th St., Oakland, Calif. M

Circle 612 on Page 19

Power Supplies

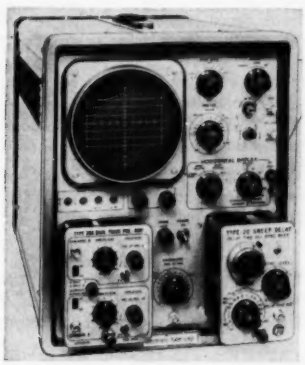
are silicon-transistor regulated

High-temperature power supplies are precision-regulated and operate at temperatures from −55 to 120 C. They are silicon-transistor regulated with silicon rectifiers, tantalum capacitors, and zener diode reference. Other characteristics include low ripple and low output impedance. **Arnoux Corp.**, 11924 W. Washington Blvd., Los Angeles 66, Calif. L

Circle 613 on Page 19

Wide-Band Oscilloscope

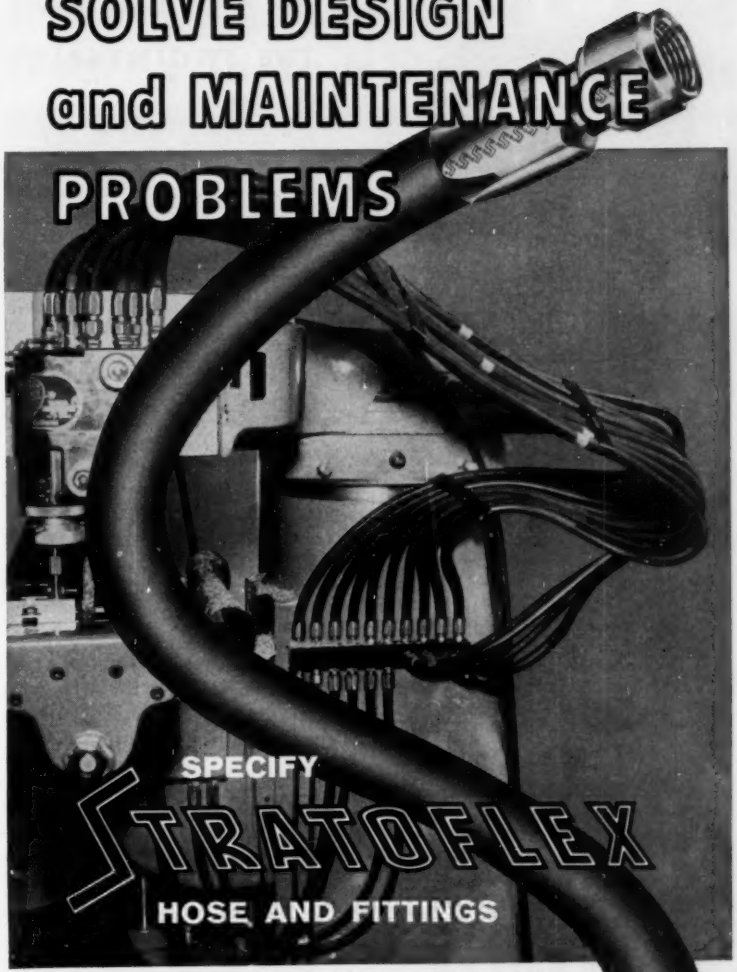
incorporates plug-in sweep delay



K-120 single-channel oscilloscope incorporates an accurate, plug-in sweep delay with 18 calibrated ranges from 2 mu sec to 1 sec per cm. Other features include wide-band vertical amplifier with 0.117 mu sec rise time, sweep lock-out, beam position indicators, single-knob calibrator and sweep controls, and others that simplify operation and waveform analysis. Frame-grid twin triodes and silicon-diode rectifiers are used for maximum reliability. Unit is general-purpose laboratory instrument for fast circuit work in pulse applications such as radar, guidance systems, and nuclear work. **Electronic Tube Corp.**, 1200 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 614 on Page 19

SOLVE DESIGN and MAINTENANCE PROBLEMS



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Circle 492 on Page 19

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Circle 493 on Page 19

THE ENGINEER'S Library

Recent Books

Engineering Mechanics. *By Dwight F. Gunder and Derald A. Stuart; 391 pages, 5¾ by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.75 per copy postpaid.*

Vector notation and rigorous mathematics are featured in this text. New problems point out the applications of mechanics in both classical and modern technology. After basic concepts, definitions, and vectors are introduced, statics continues with simple physical problems, work, energy, friction, and flexible cables. Dynamics deals with particle motion, relative motion, rigid bodies, and vibrations.

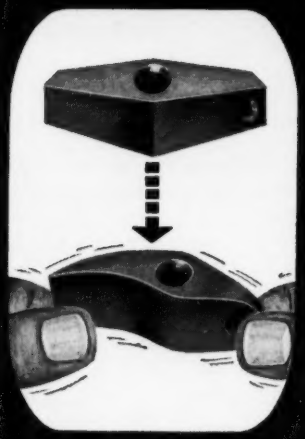
Performance of Lubricating Oils. *By H. H. Zuidema; 205 pages, 6 by 9 in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$7.00 per copy postpaid.*

Oxidation, bearing corrosion, sludge formation, and wear are some of the basic performance characteristics discussed in this second edition. Although most of the information is based on work done on automotive lubricants, conclusions apply to related lubrication problems. The effect of each refining-process step on final performance characteristics is briefly mentioned.

Selected papers on lubricating oil technology written in the last seven years have provided new references for chapter bibliographies. Corresponding text revisions and additions have been made. New subjects include multigrade motor oils, fretting wear, and paper chromatography.

Kinetic Analysis of Mechanisms. *By Joseph Edward Shigley, associate professor of mechanical engineering, University of Michigan; 351 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York*

just to *stretch* a point.



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Circle 494 on Page 19

36, *N. Y.; available from* MACHINE DESIGN, *$7.75 per copy postpaid.*

A common language background and integration of new developments are provided by this text. Graphical and analytical methods are given equal use. Vector analysis is accomplished with both complex rectangular notation and complex polar notation which facilitates use of computers to obtain solutions. Mechanism motion is also expressed in the form of an algebraic equation wherever possible.

Initial chapters present fundamentals, terms, and tools for analysis and synthesis. Final chapters deal with several kinds of gears, mechanism trains, linkages, cams, space mechanisms, and analog computer mechanisms.

Association Publications

Organizing for Product Development—Management Report 31. *115 pages, 6 by 9 in., paperbound; published by and available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.00 per copy.*

In the papers comprising this report, leaders of research and engineering programs describe various aspects of new-product development from establishment of corporate objectives to integration of the overall program. Relating research to sales and meeting financial requirements of development programs are discussed. Other phases of the program cover organization for research, engineering, and commercial development.

Aluminum Construction Manual. *389 pages, 6 by 9 in., clothbound; published by and available from the Aluminum Association, 420 Lexington Ave., New York 17, N. Y.; $3.00 per copy.*

Intended primarily for civil engineering uses, this first edition presents reference information on aluminum structural shapes, giving dimensions and standard tolerances, weights, and properties. A section on detailing practice contains data on riveted and bolted connections. Sample calculations of allowable loads and load tables for 6061-T6 beams and columns are included. Standards and specifications cover the nine most commonly used structural alloys.

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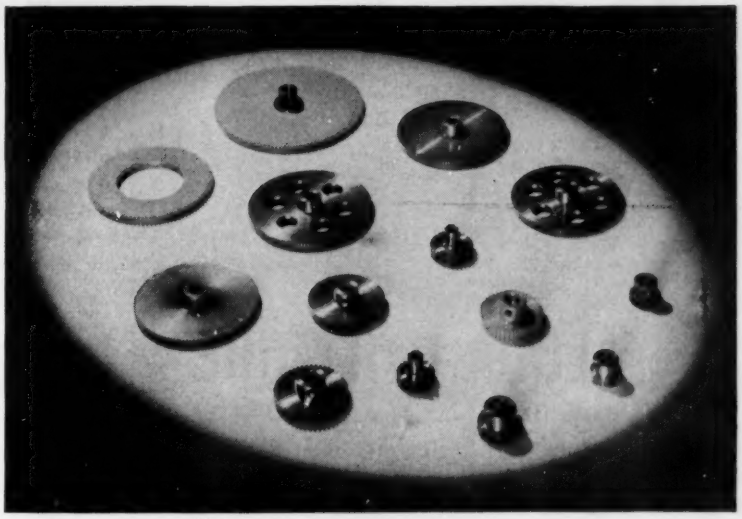

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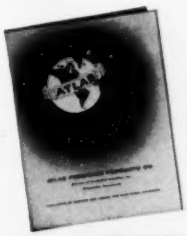

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Patents

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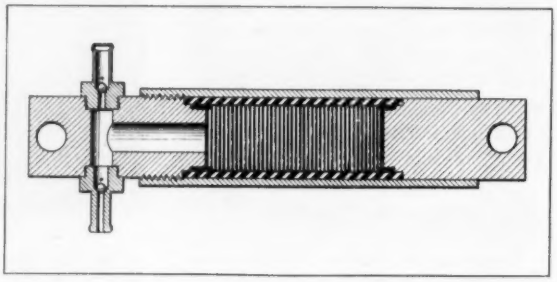
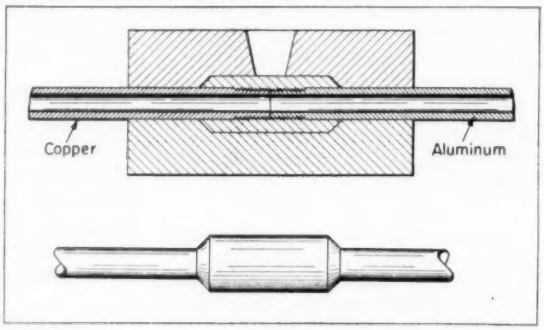
In a piston pump, the need for a close fit of the piston in the cylinder is eliminated by a resilient pressure chamber. The chamber is a tube of resilient material reinforced inside by a cylindrical spring. Ends



of the tube are bonded fluid-tight to the piston and the pump body. Threaded to the pump body is a sleeve which limits radial expansion of the resilient tube and contains the reciprocating piston. *Patent* 2,902,944 *assigned to Chamberlain Corp., Waterloo, Iowa, by Nicholas L. Etten.*

Fused Aluminum-Copper Tube Joint

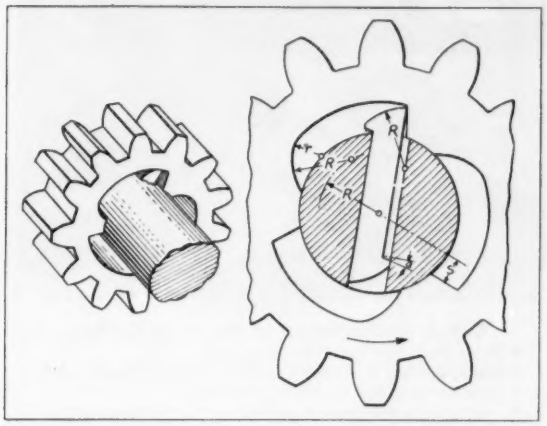


Aluminum and copper tubes are joined by a cast-on aluminum ferrule to form a leakproof connection for fluids under pressure. Threaded ends of the tubes are butted together inside a mold which receives the molten aluminum. Mechanical interlock between threads and ferrule is augmented by intermetallic fusion which occurs at the tips of the threads to prevent loosening of the joint members. *Patent* 2,903,763 *assigned to General Motors Corp. by Leland H. Grenell.*

Overrunning Shuttle-Pin Clutch

Within a resilient plastic gear, which is driving continuously in one direction, recessed surfaces enable

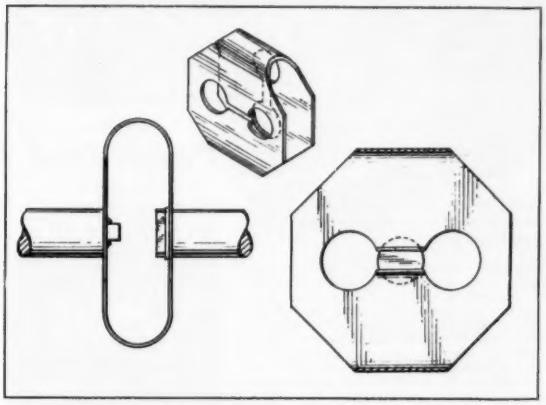
frequent overrunning by displacing a floating metal pin in a slot through a driven shaft. Driving and



driven members are held engaged by a lip on the pin. During overrunning, the pin is cammed out of engagement by internal gear contours shaped nearly the same as the pin head. *Patent* 2,905,294 *assigned to Clemson Bros. Inc., Middletown, N. Y., by Charles T. Kellogg.*

Flexible Antibacklash Shaft Coupling

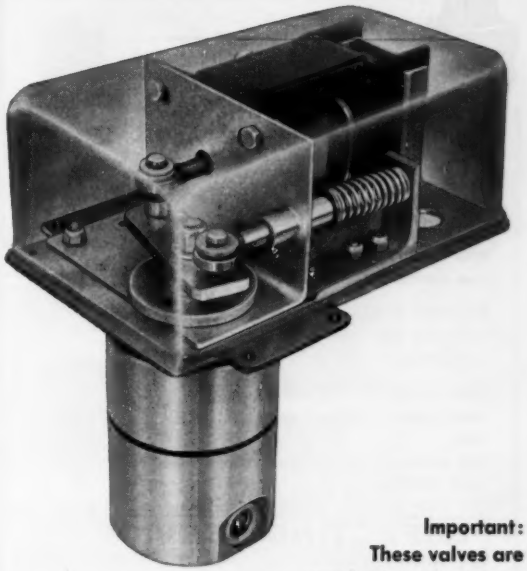
A one-piece sheet metal shaft coupling, bent in an oval shape, accommodates parallel misalignment, angular displacement, and end play between two shafts.



Coupling faces are in the shape of an octagon. This shape is punched perpendicular to the axis of flattened resilient tubing which is the original material. Opposite walls have slots which are forced onto tongues on the ends of the two shafts. Pairs of holes are punched into the opposite faces of the coupling to limit the widths of the slots and to assure leaf-spring action. *Patent* 2,903,-867 *assigned to Lear Inc., Grand Rapids, Mich., by Steven M. Moody.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commssioner of Patents, Washington 25, D. C.

10,000 P.S.I. SOLENOID VALVES



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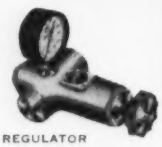

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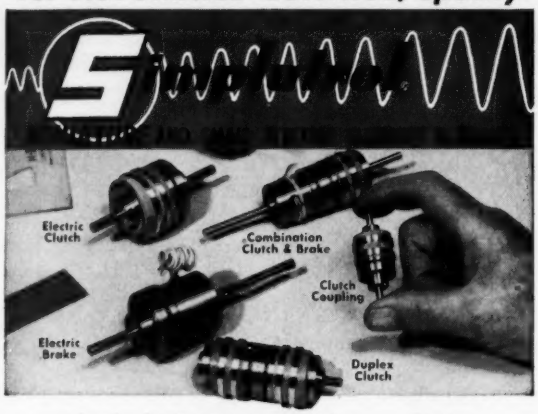

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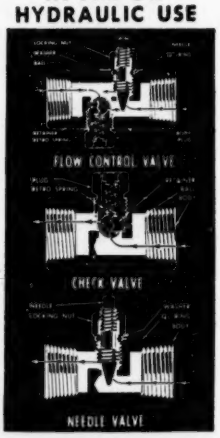

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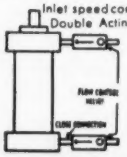

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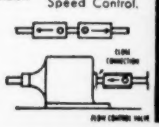

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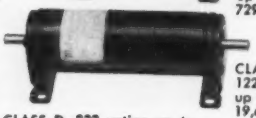

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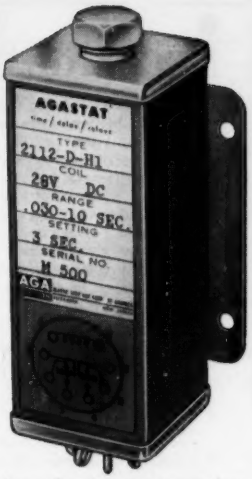

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BPA NBP

backtalk——

—Granddaughter of the Duster

Chrysler Corp. enters the ready-to-wear business by sponsoring an exclusive collection of women's clothing made in colors related to the new Imperials. Jules Francois Crahay, a designer for the French couturier Nina Ricci and "the brightest new star on the fashion horizon," has dreamed up six outfits including suits, dresses, and evening gowns for the Imperial Collection. Come the middle of next January, the ladies will be able to pick up these outfits in Saks Fifth Ave. stores and other shops which cater to the carriage trade. The particular carriage which served as inspiration, incidentally, is shown on Page 26 of this issue.

—A Case of Accurate Identity

While undergoing editorial and mechanical preparations for publication, MACHINE DESIGN articles are usually identified simply by the surnames of their authors. This system can be complicated only when two articles by the same author are in the works simultaneously, whereupon we merely expand the identification to include a brief phrase indicating the subject. While the article, "Volunteering Technical Services," Page 107 of this issue, was being edited another contribution by Albert Woodruff Gray was scheduled, so the first one became "Gray—Good Sam" on our records because of the Good Samaritan aspect of its content. Copy was dispatched to the linotype department, and presently a galley proof came from one of our warm-hearted typesetters bearing the laudatory heading "Good Sam Gray." Well, he may not answer to the name of Sam, but Mr. Gray is a mighty good man to have available when information on the legal aspects of engineering is needed.

—Calling All Little Thinkers

Designers of wrist radios, machines for engraving on pinheads, and other miniature equipment are invited to enter the 1959 Miniaturization Awards Competition sponsored by Miniature Precision Bearings Inc., Keene, N. H. This competition is open to individuals, companies, or organizations that have advanced the field of miniaturization by furthering the use of the concept through education, research, engineering, or standardization, or have developed products, components, or assemblies that solve miniaturization problems, make use of new design concepts or materials, or use components or assemblies of advanced design. A bronze sculpture symbolizing miniaturization will be presented to the winner of the competition, and ten certificates of excellence will also be awarded. Details on entries, which must be submitted by January 20, 1960, are available from: Miniaturization Awards Committee, P. O. Box 604, Keene, N. H.

—American Standard Time

Mention of miniaturization brings to mind the American standard on Unified Miniature Screw Threads, which illustrates that the wheels of standardization grind exceedingly fine, although sometimes slowly. A foreword to the standard states that standardization of threads for miniature fastening screws and similar purposes had been under study since 1927. Action at that time consisted of compiling practices of American manufacturers and various foreign standards. Something less than enthusiasm prevailed at that point, and the list sat around unused until 1943 when wartime requirements re-emphasized the need for both domestic and foreign standardization. In 1944 the American Standards Association established a committee on instrument screw threads. Decisions on sizes, thread angles, and such were reached during the next dozen years. Recently, one of our editors, who worked on the standard while he was with Hamilton Watch Co. in the 1940's, received a copy of the finally approved standard. With it was a form letter—dated six weeks prior to the day it arrived.

—Pushing Plastics

Newton's basic law (that's Sir Figg Newton, inventor of the extruded cookie) states that the producibility of an extrusion is inversely proportional to the complexity of its cross-section. Although shapes of plastic extrusions, usually more complicated than a cookie, must be governed by limitations of the process, extruding is often more economical than injection molding, machining, or vacuum forming. The merits of plastic extrusions and basic rules for designing them will be discussed in a comprehensive article in the November 12 issue of MACHINE DESIGN. Title of the article is, appropriately, "Designing Plastic Extrusions."

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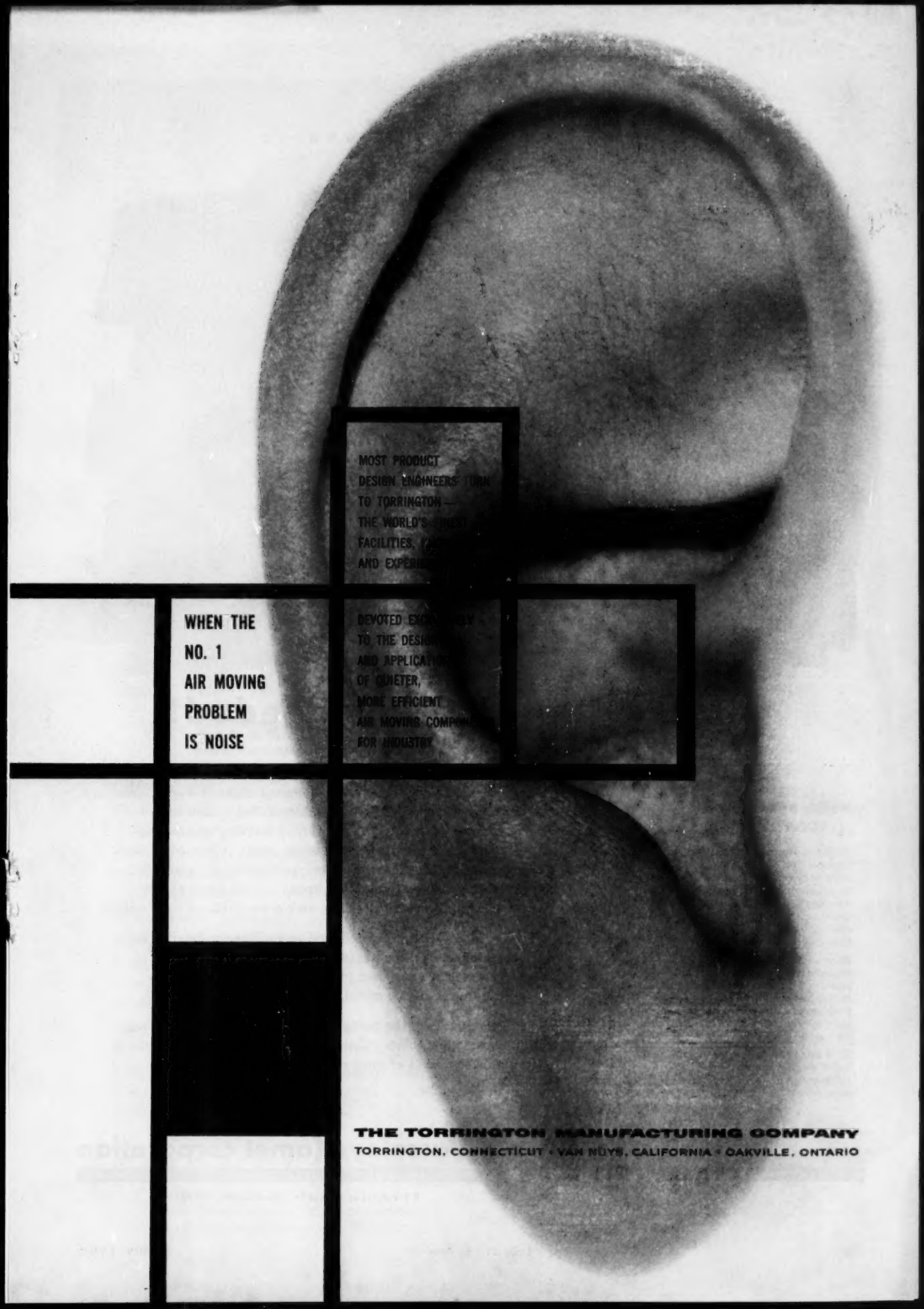
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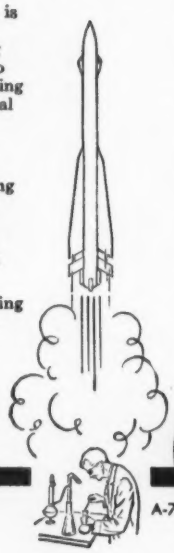

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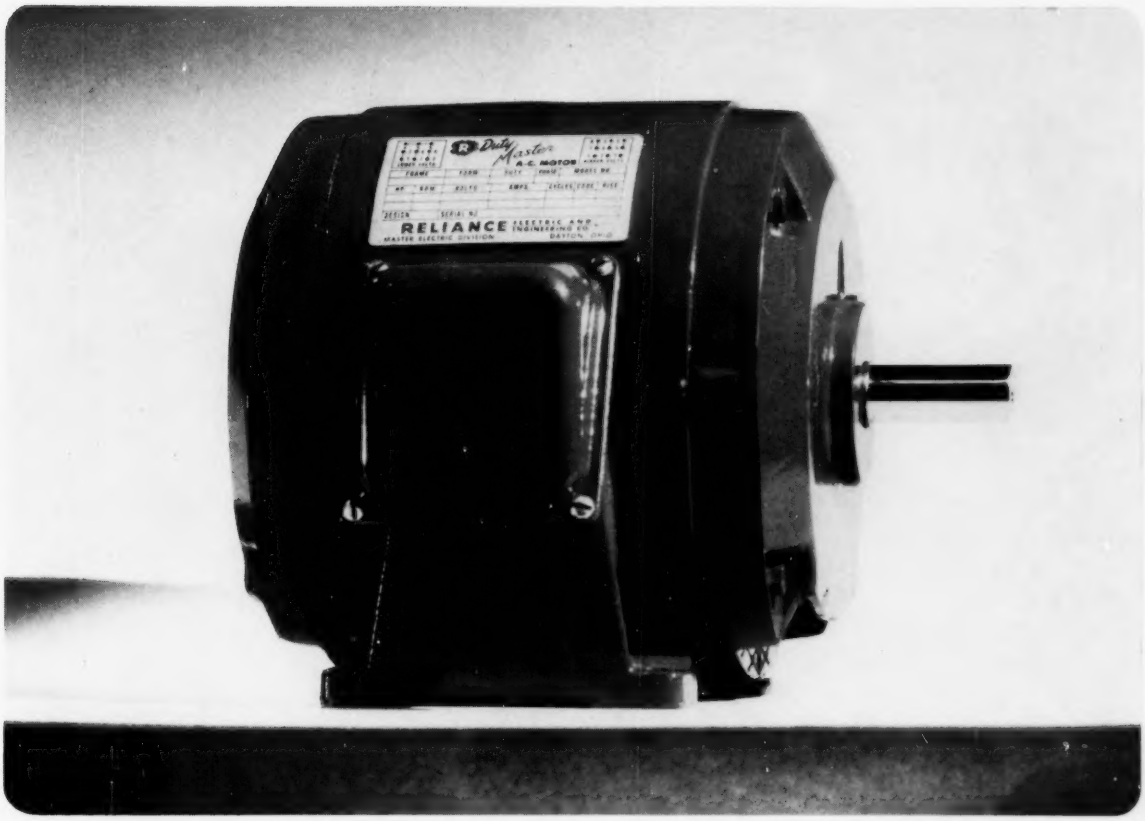

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MASTER REEVES R

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Why Cross chose Timken® bearings for all 148 drill spindles

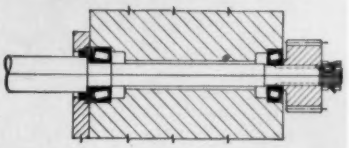
THIS huge Cross transfer machine drills and taps holes in automobile engine blocks at new highs in speed and accuracy. To assure maximum user economy and machine life, Cross engineers chose Timken® tapered roller bearings for the machine's 148 drill spindles. Here's why:

1) *They maintain precision longer.* Timken bearings are geometrically designed to give true rolling motion, precision manufactured to live up to their design.

2) *They're extra tough* because Timken bearings are made of the finest bearing-quality alloy steel available.

When you use a machine with Timken bearings, you get all the *extra* benefits of Timken Company leadership in tapered roller bearing design and in engineering service. We maintain the industry's most modern laboratory to test bearing applications. To get better machines, make sure they're Timken bearing-equipped. ***When you buy Timken bearings you get...*** *1) Quality you can take for granted. 2) Service you can't get anywhere else. 3) The best-known name in bearings. 4) The pace setter in lower bearing costs.* The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

How **THE CROSS CO.** mounts 148 drill spindles of its Transfermatic on Timken bearings to give longer bearing life, maintain accuracy.



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